US009415496B2

(12) **United States Patent**
Harrington et al.

(10) **Patent No.: US 9,415,496 B2**
(45) **Date of Patent: Aug. 16, 2016**

(54) **DOUBLE WALL FLOW TUBE FOR PERCUSSION TOOL**

(71) Applicant: **Varel Interational Ind., L.P.**, Carrollton, TX (US)

(72) Inventors: **David Harrington**, Dallas, TX (US); **Anthony Plana**, Prosper, TX (US)

(73) Assignee: **VAREL INTERNATIONAL IND., L.P.**, Carrollton, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 300 days.

(21) Appl. No.: **14/079,323**

(22) Filed: **Nov. 13, 2013**

(65) **Prior Publication Data**

US 2015/0129315 A1 May 14, 2015

(51) **Int. Cl.**
E21B 4/14 (2006.01)
B25D 9/16 (2006.01)

(52) **U.S. Cl.**
CPC ... ***B25D 9/16*** (2013.01); ***E21B 4/14*** (2013.01); *Y10T 29/49229* (2015.01)

(58) **Field of Classification Search**
CPC E21B 4/14; B25D 9/16; Y10T 29/49229
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,871,319 A 8/1932 Griswold et al.
2,353,652 A 7/1944 Coonrod
2,494,803 A 1/1950 Frost et al.
3,065,807 A 11/1962 Wells
3,101,796 A 8/1963 Stall et al.
3,265,091 A 8/1966 De Jarnett
3,353,607 A 11/1967 Kinley
3,379,261 A 4/1968 Martini
3,471,177 A 10/1969 Garrett et al.
3,586,104 A 6/1971 Hyde
3,638,970 A 2/1972 Sandquist et al.
3,664,441 A 5/1972 Carey
3,747,698 A 7/1973 Chapman

(Continued)

FOREIGN PATENT DOCUMENTS

WO 9532355 11/1995
WO 9832945 7/1998

(Continued)

OTHER PUBLICATIONS

Young, Lee W., International Search Report and Written Opinion of the International Searching Authority for PCT/US2014/065428, Jan. 15, 2015, pp. 1-8.

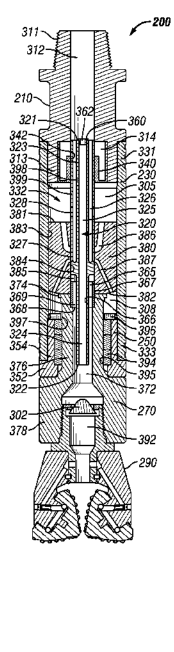
(Continued)

Primary Examiner — Brad Harcourt

(57) **ABSTRACT**

An apparatus, system, and method of fabricating a percussion tool that includes a flow tube. The flow tube includes upper and lower portions, inner and outer walls, and at least one opening formed in the outer wall. The upper portion extends from a top end towards a bottom end. The lower portion extends from the upper portion to the bottom end. The inner wall extends from the top end to the bottom end and defines a central channel therein. The outer wall extends from the top end towards the bottom end, surrounds a portion of the inner wall and defines an outer channel with the inner wall. The opening is fluidly communicable with a first conduit formed within a piston, which surrounds a portion of the flow tube, when in an up position and is fluidly communicable with a second conduit formed within the piston when in a down position.

25 Claims, 11 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

3,786,878	A	1/1974	Chapman	
3,795,283	A	3/1974	Oughton	
3,860,272	A	1/1975	Becker	
3,928,903	A	12/1975	Richardson et al.	
3,964,551	A	6/1976	Bassinger	
3,970,335	A	7/1976	Curington et al.	
3,998,479	A	12/1976	Bishop	
4,012,061	A	3/1977	Olson	
4,067,596	A	1/1978	Kellner et al.	
4,070,043	A	1/1978	Becker	
4,106,571	A	8/1978	Stone	
4,149,739	A	4/1979	Morris	
4,185,704	A	1/1980	Nixon, Jr.	
4,190,073	A	2/1980	Claycomb	
4,257,442	A	3/1981	Claycomb	
4,280,535	A	7/1981	Willis	
4,280,570	A	7/1981	Walter	
4,281,678	A	8/1981	Claycomb	
4,282,942	A	8/1981	Longmore	
4,337,563	A	7/1982	Becker et al.	
4,337,788	A	7/1982	Seger	
4,385,668	A	5/1983	Becker et al.	
4,402,370	A *	9/1983	Gein	E21B 4/14 173/135
4,444,220	A	4/1984	Seger	
4,470,430	A	9/1984	Lancaster	
4,565,394	A	1/1986	Becker	
4,618,172	A	10/1986	Becker	
4,644,974	A	2/1987	Zingg	
4,662,401	A	5/1987	Zingg et al.	
4,665,996	A	5/1987	Foroulis et al.	
4,705,118	A	11/1987	Ennis	
4,784,223	A	11/1988	Worrall et al.	
4,819,746	A	4/1989	Brown et al.	
4,872,507	A	10/1989	Ronco, Sr. et al.	
4,913,466	A	4/1990	Becker	
4,951,409	A	8/1990	Froid	
5,029,646	A	7/1991	Blizzard, Jr.	
5,095,994	A	3/1992	Dollison	
5,186,266	A	2/1993	Heller	
5,190,106	A	3/1993	Johnston	
5,217,046	A	6/1993	Woods	
5,246,074	A	9/1993	Ayres	
5,253,708	A	10/1993	Alexander	
5,365,978	A	11/1994	Woods	
5,396,965	A	3/1995	Hall et al.	
5,505,261	A	4/1996	Huber et al.	
5,535,767	A	7/1996	Schnatzmeyer et al.	
5,562,357	A	10/1996	Sandell	
5,623,966	A	4/1997	Rodger	
5,713,423	A	2/1998	Martin et al.	
5,862,866	A	1/1999	Springer	
5,906,238	A	5/1999	Carmody et al.	
5,957,207	A	9/1999	Schnatzmeyer	
5,957,208	A	9/1999	Schnatzmeyer	
5,992,520	A	11/1999	Schultz et al.	
6,073,698	A	6/2000	Schultz et al.	
6,082,458	A	7/2000	Schnatzmeyer	
6,260,616	B1	7/2001	Carmody et al.	
6,334,486	B1	1/2002	Carmody et al.	
6,371,208	B1	4/2002	Norman et al.	
6,450,255	B2	9/2002	Carmody et al.	
6,484,800	B2	11/2002	Carmody et al.	
6,612,547	B2	9/2003	Carmody et al.	
6,659,202	B2	12/2003	Runquist et al.	
6,668,935	B1	12/2003	McLoughlin et al.	
6,715,558	B2	4/2004	Williamson	
6,722,439	B2	4/2004	Garay et al.	
6,860,330	B2	3/2005	Jackson	
6,892,818	B2	5/2005	Mentesh et al.	
6,966,380	B2	11/2005	McLoughlin et al.	
6,973,974	B2	12/2005	McLoughlin et al.	
7,025,140	B2	4/2006	McGee	
7,134,514	B2	11/2006	Riel et al.	
7,139,219	B2	11/2006	Kolle et al.	
7,152,688	B2	12/2006	Richards	
7,152,700	B2	12/2006	Church et al.	
7,207,603	B2	4/2007	Segreto	
7,225,875	B2	6/2007	Steele et al.	
7,258,323	B2	8/2007	Dwivedi	
7,350,565	B2	4/2008	Hall et al.	
7,377,327	B2	5/2008	Jackson	
7,389,830	B2	6/2008	Turner et al.	
7,429,030	B2	9/2008	Dwivedi	
7,451,825	B2	11/2008	Jonas	
7,455,115	B2	11/2008	Loretz et al.	
7,503,395	B2	3/2009	Meijer et al.	
7,549,485	B2	6/2009	Radford et al.	
7,575,058	B2	8/2009	Franco et al.	
7,581,602	B2	9/2009	Lorger et al.	
7,681,666	B2	3/2010	Radford et al.	
7,712,540	B2	5/2010	Loretz et al.	
7,748,478	B2	7/2010	Swadi	
7,762,334	B2	7/2010	Posluszny et al.	
7,762,356	B2	7/2010	Turner et al.	
7,766,084	B2	8/2010	Churchill	
7,770,645	B2	8/2010	Jeffryes	
7,775,233	B2	8/2010	Baugh	
7,832,473	B2	11/2010	Pensgaard	
7,849,936	B2	12/2010	Hutton	
7,870,906	B2	1/2011	Ali	
7,939,142	B2	5/2011	Blue et al.	
7,954,561	B2	6/2011	Tulloch et al.	
7,980,265	B2	7/2011	Holmes et al.	
RE42,772	E	10/2011	McGee	
8,047,304	B2	11/2011	Radford	
8,109,330	B1	2/2012	Miller	
8,141,648	B2	3/2012	Darnell et al.	
8,141,657	B2	3/2012	Hutton	
8,186,444	B2	5/2012	Patel	
8,196,679	B2	6/2012	Radford	
8,220,563	B2	7/2012	Bangaru et al.	
2004/0188146	A1	9/2004	Egerstrom	
2006/0231150	A1	10/2006	Jamison	
2008/0236842	A1	10/2008	Bhavsar et al.	
2009/0095471	A1	4/2009	Guignard et al.	
2009/0151790	A1	6/2009	Ranjan et al.	
2009/0283331	A1	11/2009	Heath	
2010/0012380	A1	1/2010	Swadi	
2010/0044111	A1	2/2010	Marshall	
2010/0270034	A1	10/2010	Clausen, Jr.	
2010/0288557	A1	11/2010	Radford	
2010/0294495	A1	11/2010	Clarkson et al.	
2011/0000684	A1	1/2011	Charles et al.	
2011/0088953	A1	4/2011	Rainey et al.	
2011/0168408	A1	7/2011	Watson	
2011/0220415	A1	9/2011	Bailey et al.	
2011/0308861	A1	12/2011	Radford	
2012/0205122	A1	8/2012	Peter et al.	

FOREIGN PATENT DOCUMENTS

WO	9904130	1/1999
WO	0131167	5/2001
WO	2008112332	9/2008
WO	2009009281	1/2009

OTHER PUBLICATIONS

Young, Lee W., International Search Report and Written Opinion of the International Searching Authority for PCT/US2014/065424, Jan. 15, 2015, pp. 1-10.

Thomas, Shane, International Search Report and Written Opinion of the International Searching Authority for PCT/US2015/014883, Apr. 15, 2015, pp. 1-8.

Thomas, Shane, International Search Report and Written Opinion of the International Searching Authority for PCT/US2015/065435, Jan. 21, 2015, pp. 1-10.

* cited by examiner

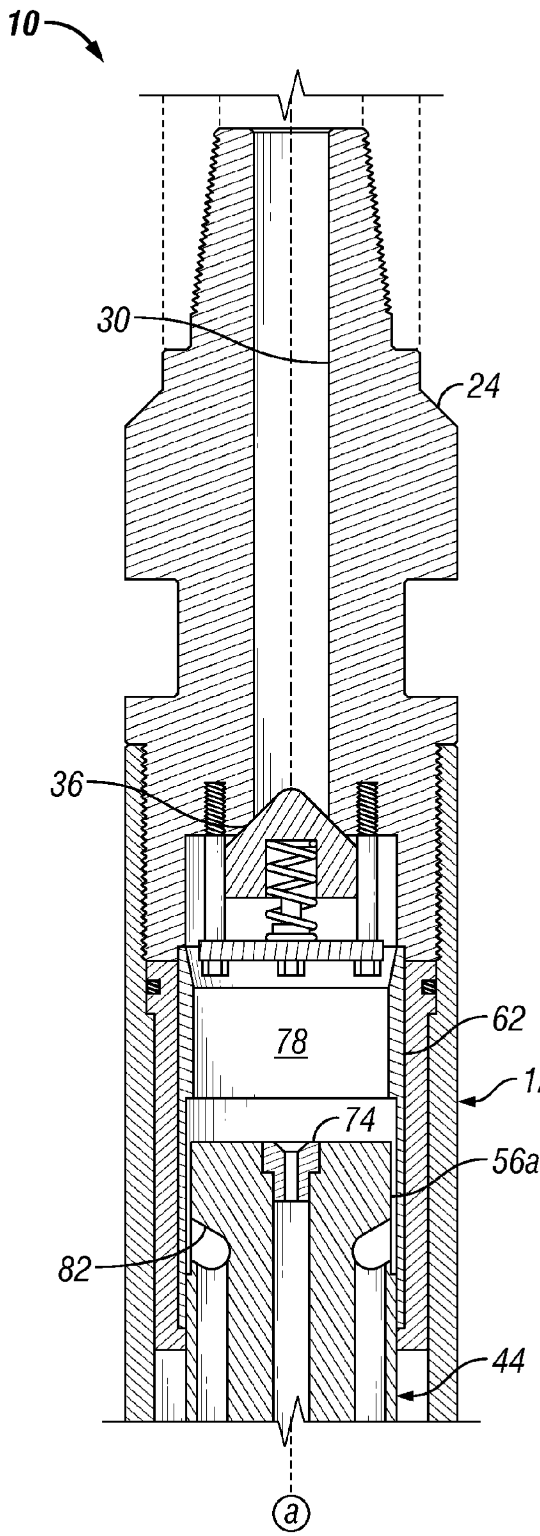


FIG. 1A
(Prior Art)

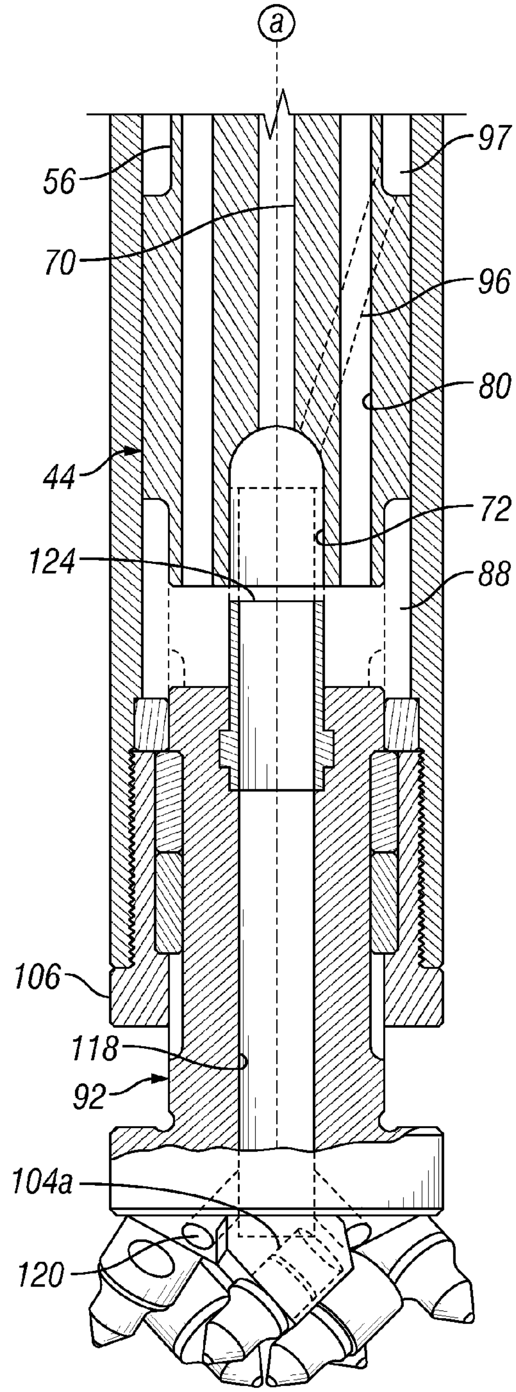


FIG. 1B
(Prior Art)

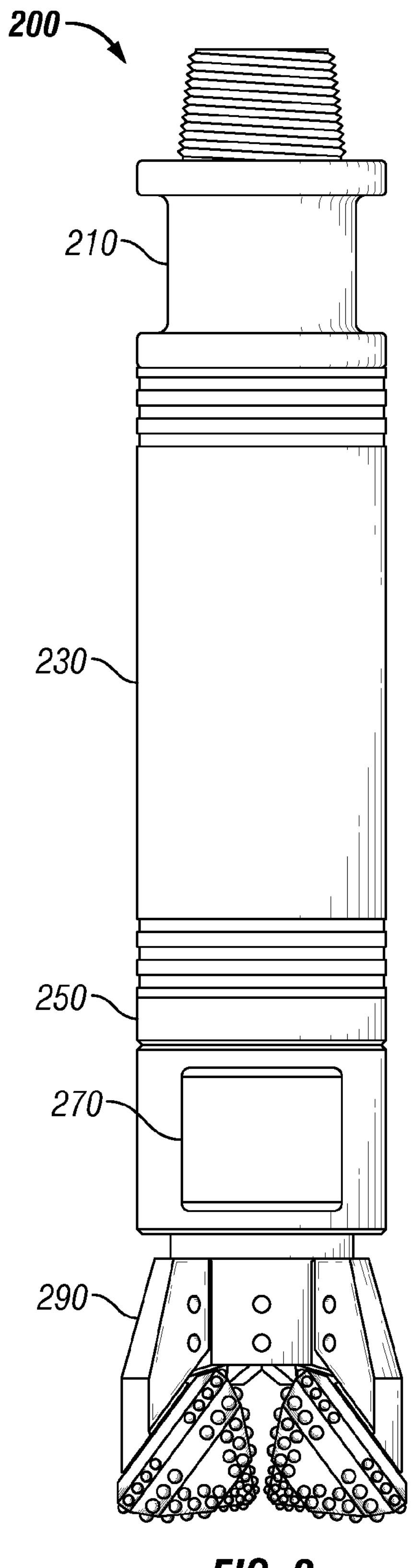

200
210
230
250
270
290

FIG. 2

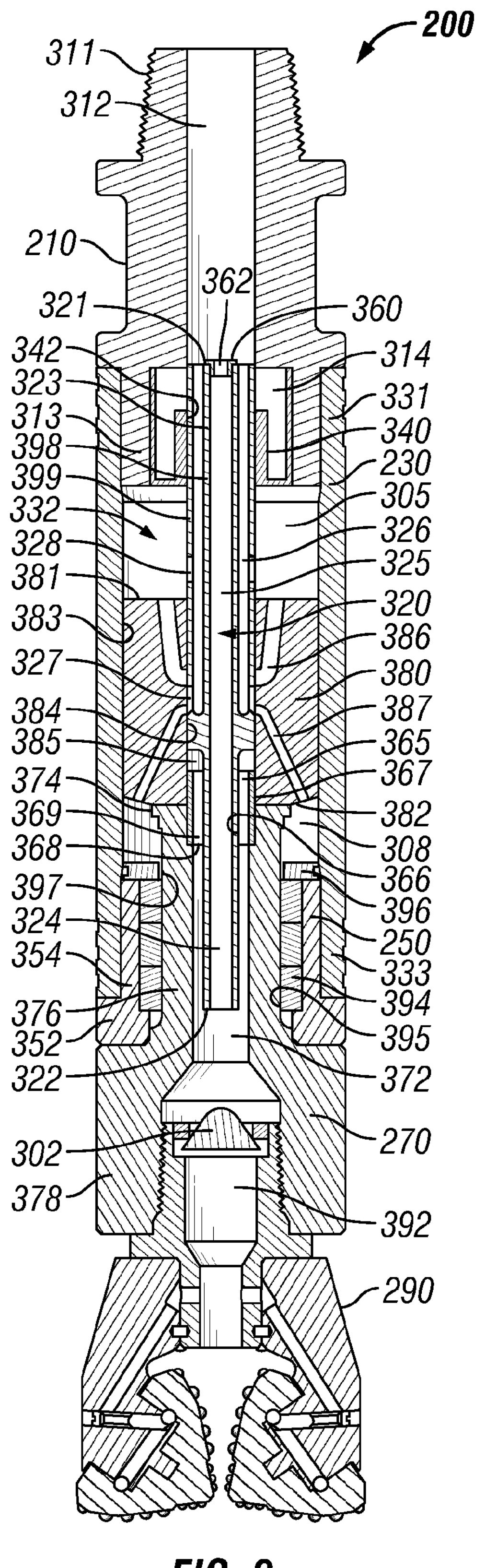

200
311
312
210
321
362
360
342
314
323
331
313
340
398
230
399
305
332
326
328
325
381
320
383
386
327
380
384
387
385
365
374
367
369
382
368
308
366
397
396
324
250
354
333
376
394
352
395
322
372
302
270
378
392
290

FIG. 3

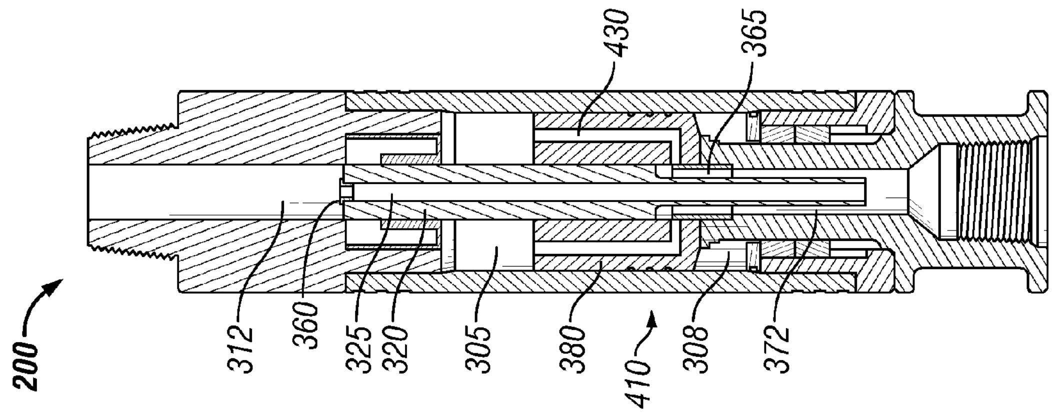


FIG. 4B-2

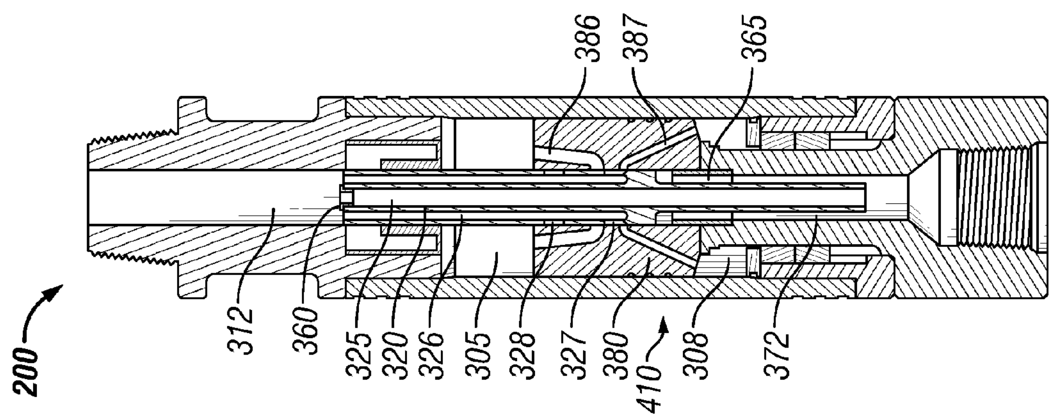


FIG. 4B-1

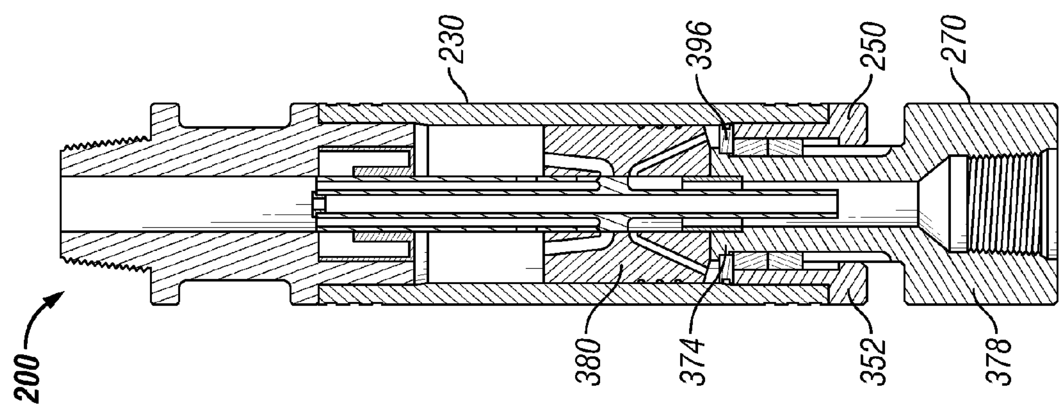


FIG. 4A

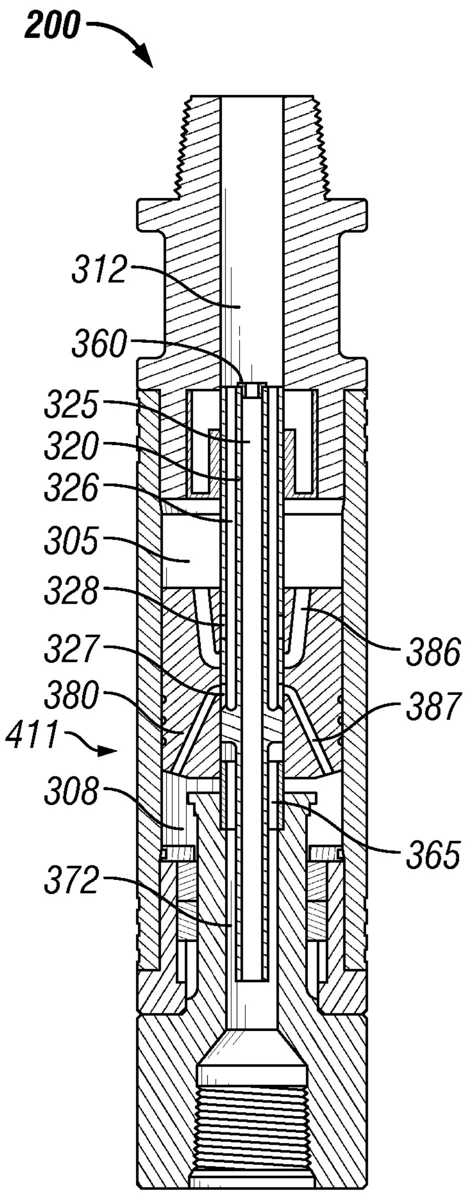


FIG. 4C-1

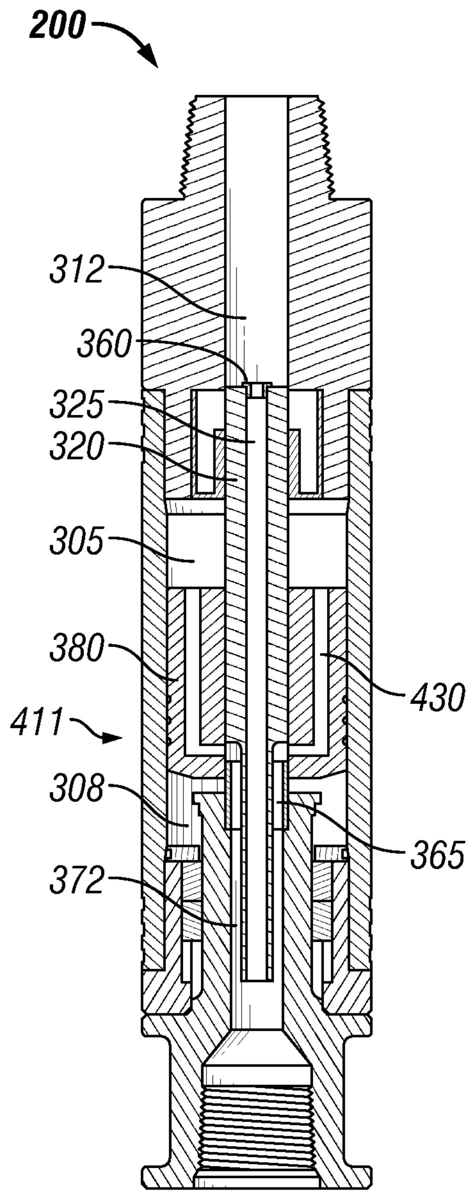


FIG. 4C-2

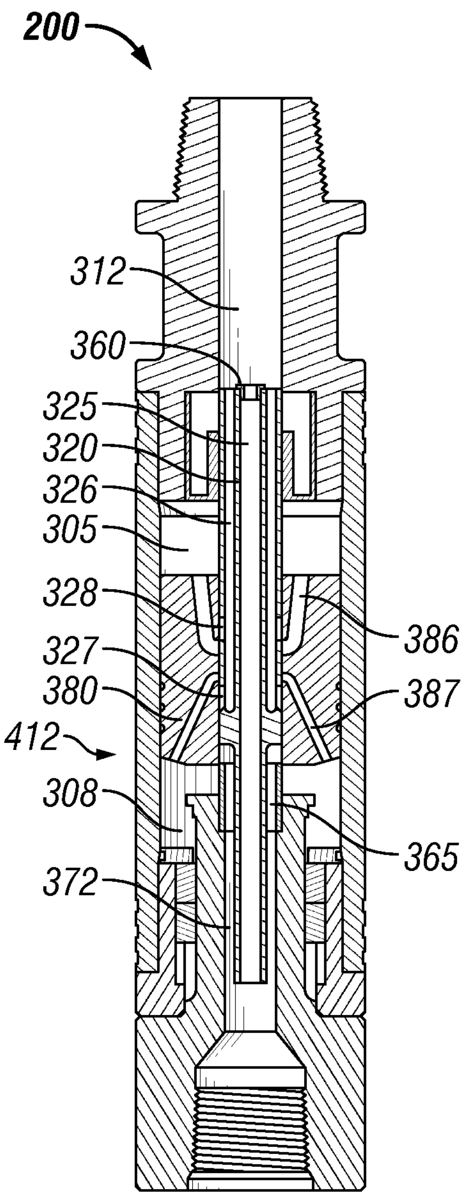


FIG. 4D-1

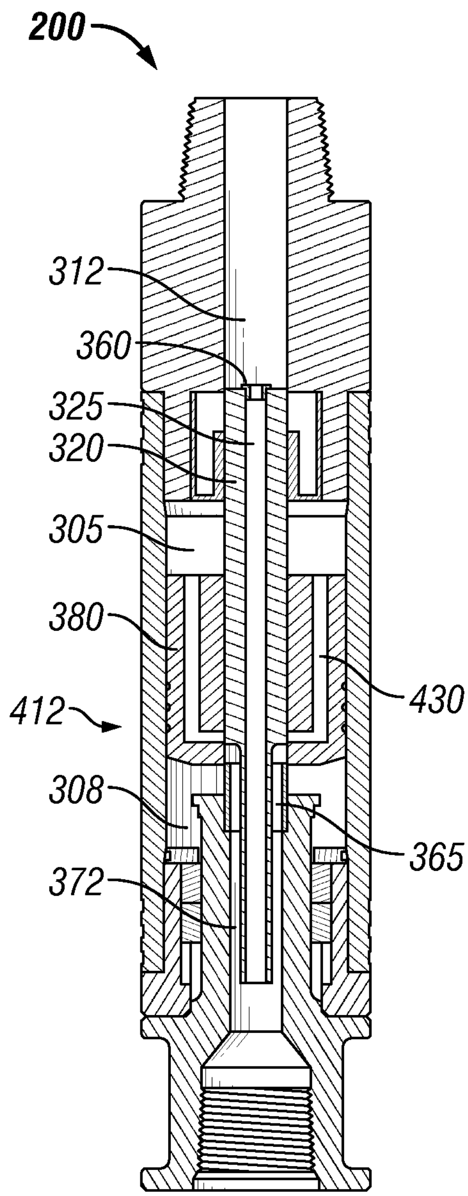


FIG. 4D-2

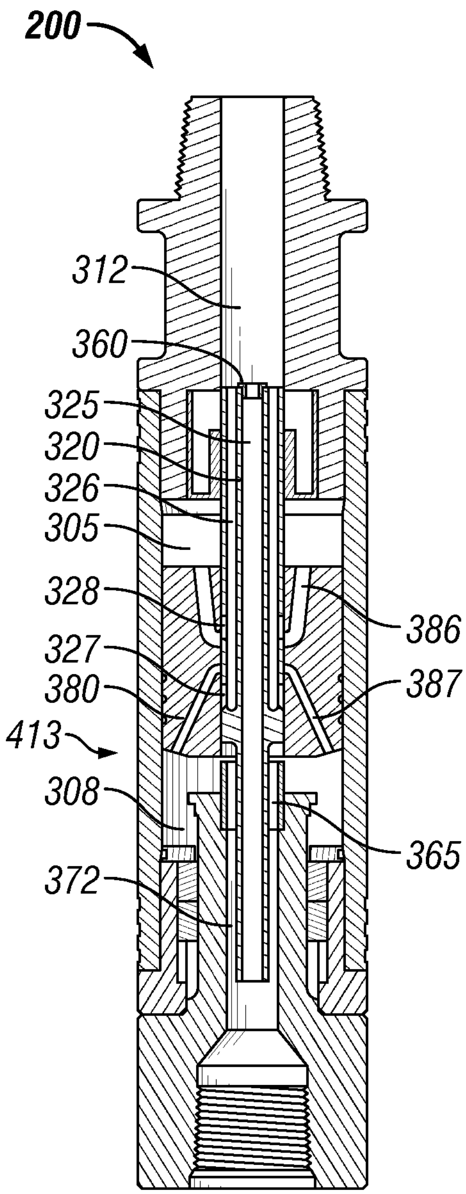


FIG. 4E-1

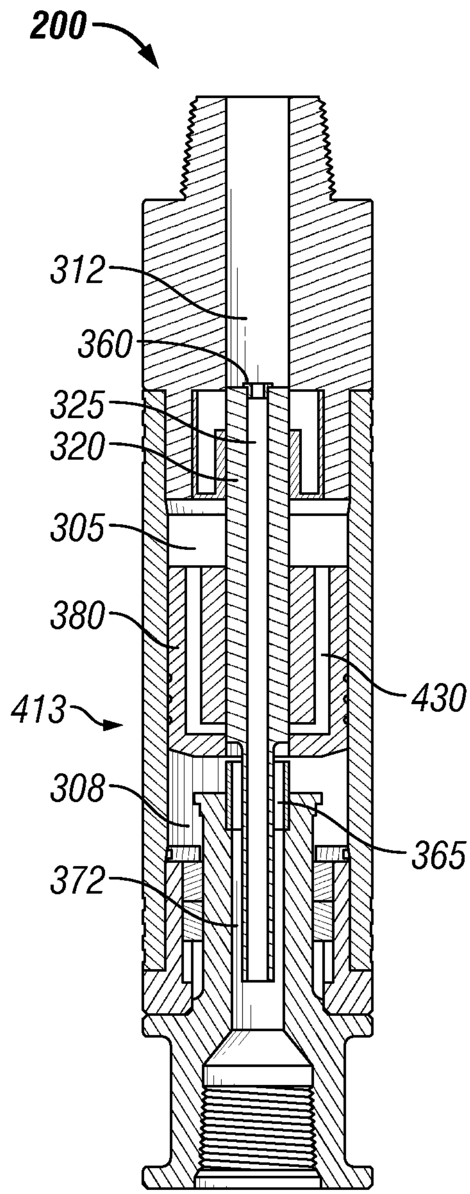


FIG. 4E-2

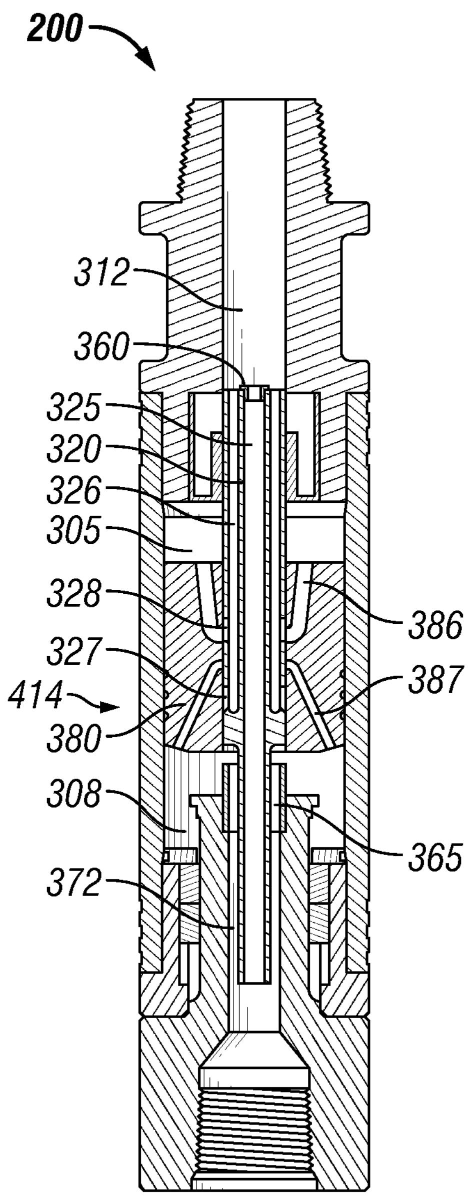


FIG. 4F-1

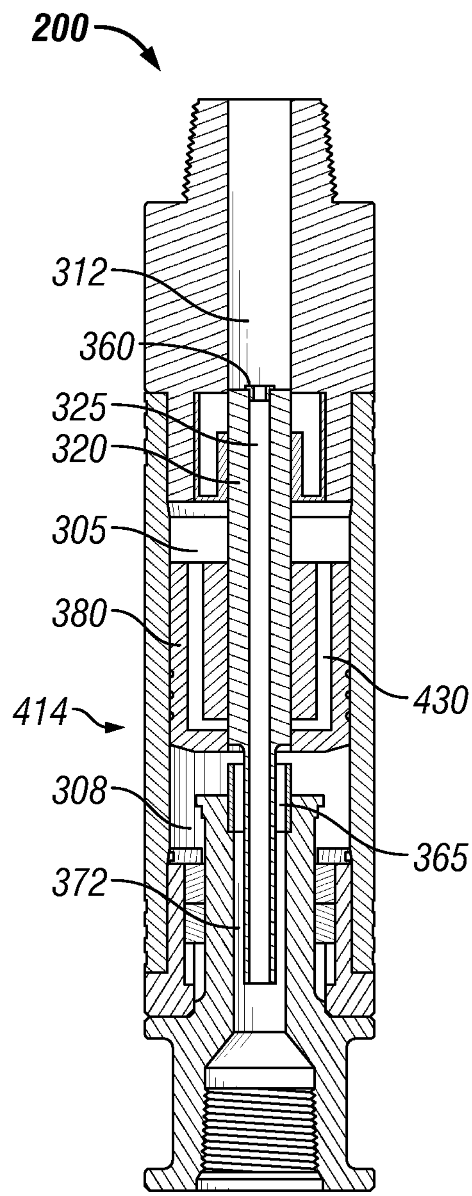


FIG. 4F-2

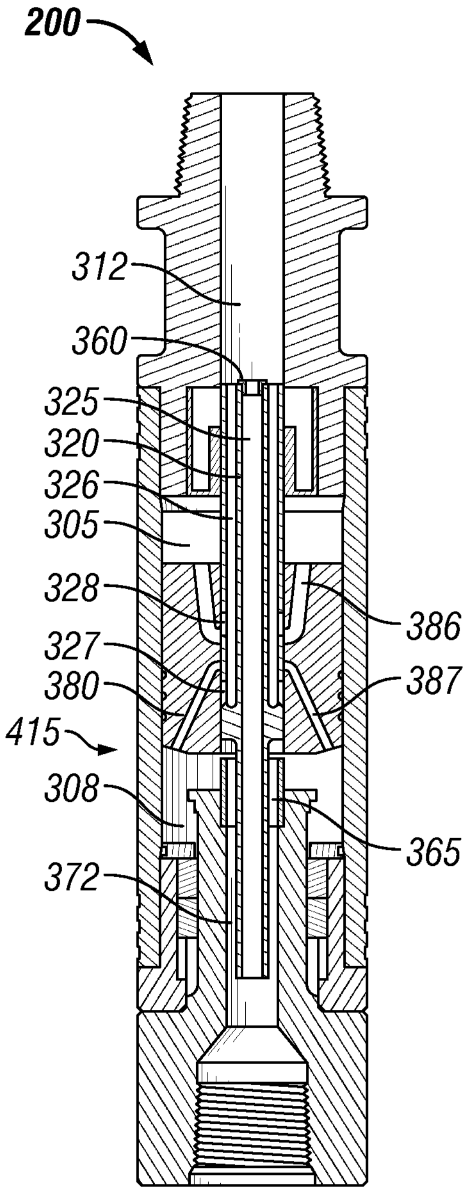


FIG. 4G-1

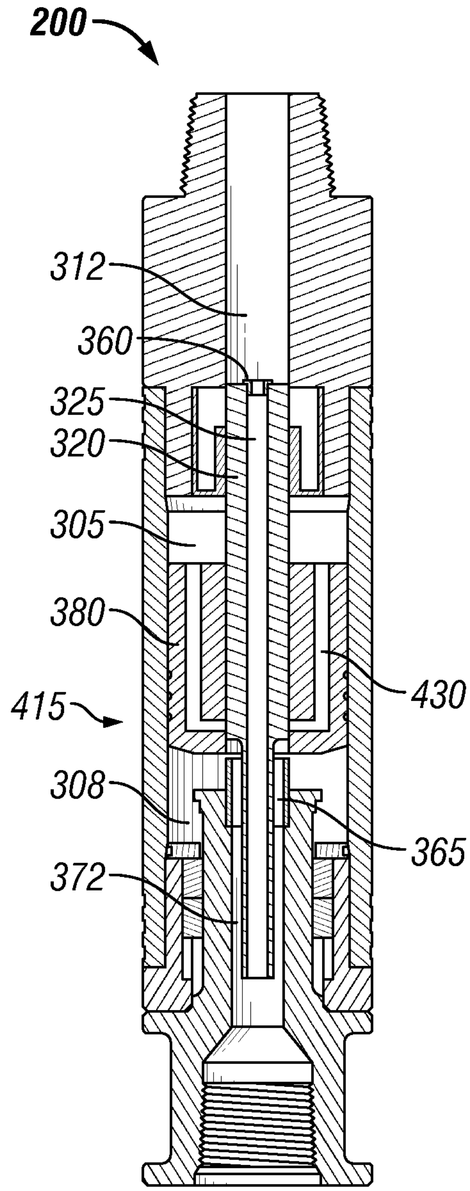


FIG. 4G-2

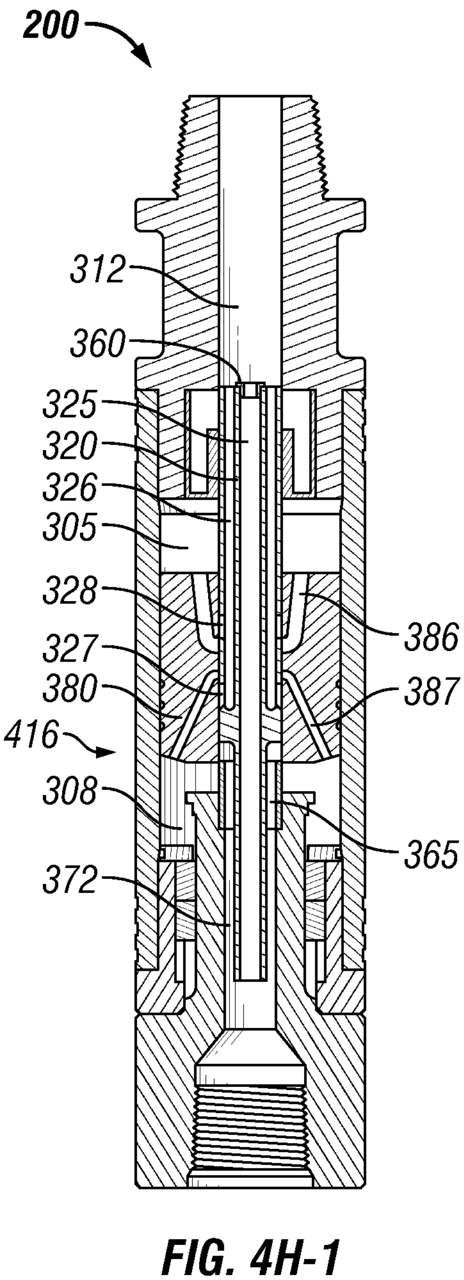


FIG. 4H-1

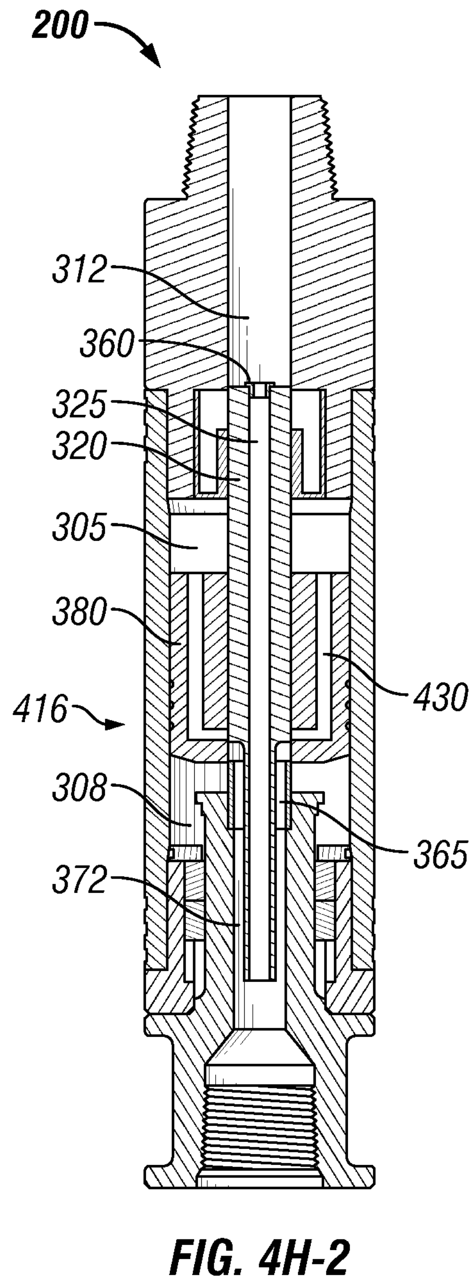


FIG. 4H-2

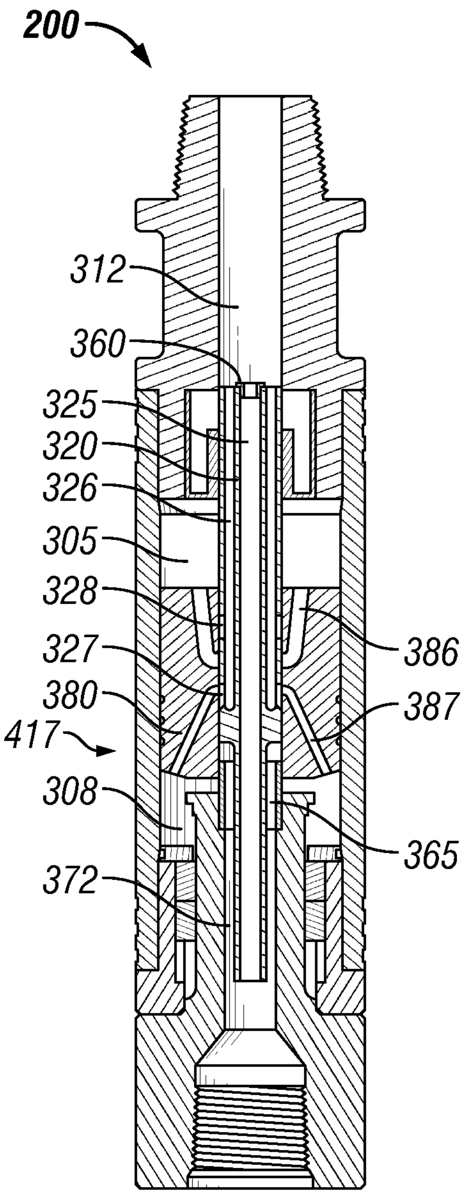


FIG. 4I-1

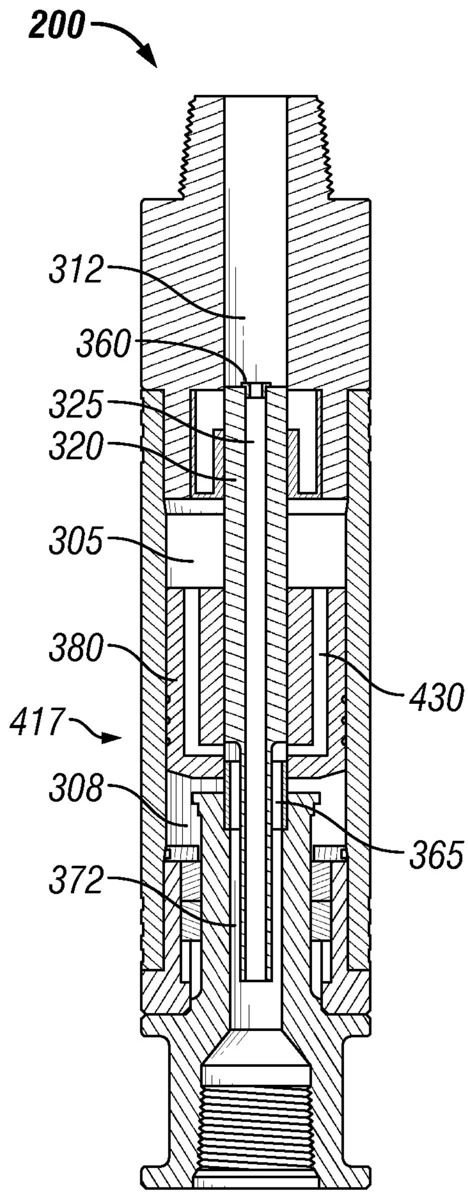


FIG. 4I-2

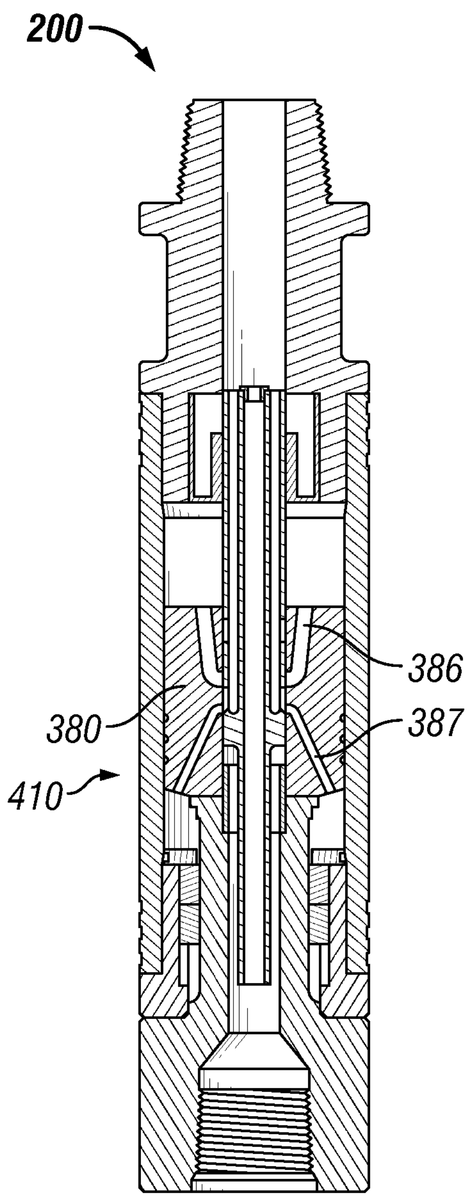


FIG. 4J-1

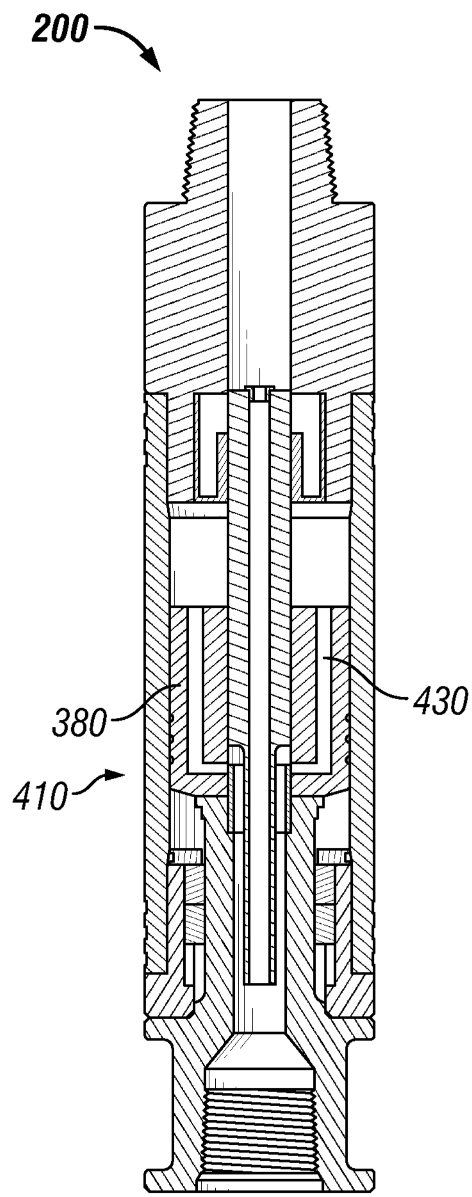


FIG. 4J-2

DOUBLE WALL FLOW TUBE FOR PERCUSSION TOOL

RELATED APPLICATIONS

The present application is related to U.S. patent application Ser. No. 14/079,342, entitled "Top Mounted Choke For Percussion Tool" and filed on Nov. 13, 2013, and U.S. patent application Ser. No. 14/079,362, entitled "Coating Of The Piston For A Rotating Percussion System In Downhole Drilling" and filed on Nov. 13, 2013, both of which are hereby incorporated by reference herein.

BACKGROUND

This invention relates generally to percussion tools used in downhole drilling. More particularly, this invention relates to an apparatus and method for controlling air flow within percussion tools, such as rotary bits, shear bits, and lighter hammer bits, used in downhole drilling.

Rotary drilling tools, such as rock bits, can benefit from percussive energy to improve drilling rate, or rate of penetration (ROP), and improve hole straightness. However, this percussive energy should be controlled. If the percussive energy is too little, the drilling tool will not create and/or propagate fractures in the rock. If the percussive energy is too much, the drilling tool life is unacceptably reduced due to bearing spalling, steel fatigue cracking, and/or other life reducing causes. Hence, to be an effective tool, the drilling tool should be efficient with low drill system pressure, but also should be able to limit percussive force at high drill system pressure.

There are currently two rotary percussion systems in the market, the PARD tool and the RPS tool. However, neither of these tools are meeting market needs. The PARD tool provides sufficient percussive force at low drill system pressures, but vents excessive air through an unreliable top vent system which commonly plugs, thereby resulting in work stoppages. The RPS tool suffers from inadequate percussive force at low drill system pressures, but vents excessive air through a central flow system which is not prone to plugging. Low drill system pressures include pressures in the sixty pounds per square inch (psi) to eighty psi range, but can be different from the provided range. There is a need to develop a tool which achieves high percussive force at low drill system pressures while reliably limiting percussive force at higher drill system pressures to avoid damage to the rock bit.

FIG. **1**A is a longitudinal cross-sectional view of a portion of a conventional downhole percussion tool **10** in accordance with the prior art. FIG. **1**B is a longitudinal cross-sectional view of a remaining portion of the conventional downhole percussion tool **10** of FIG. **1**A whereby FIG. **1**A is intended to be joined to FIG. **1**B along common line a-a in accordance with the prior art. The conventional downhole percussion tool **10** is described in detail in U.S. Pat. No. 7,377,338, which issued to Bassinger on May 27, 2008, and is incorporated by reference herein in its entirety. Thus, the conventional downhole percussion tool **10** is briefly described herein for the sake of describing airflow therein. Referring to FIGS. **1**A and **1**B, the conventional downhole percussion tool **10** includes a tool cylinder or housing **12**, a rear adapter or sub **24**, a check valve **36**, a piston **44**, a drive sub **106**, and an integrated claw bit **92**. Although an integrated claw bit is illustrated within FIG. **1**B, a bit sub (not shown) capable of receiving a claw bit, or other bit type, can be used in lieu of the integrated claw bit **92**. Once the conventional downhole percussion tool **10** is assembled, a top pressure fluid chamber **78**, an annular chamber **97**, and a bottom pressure fluid chamber **88** is formed.

The sub **24** includes a sub passage **30** extending longitudinally therein. The check valve **36** is coupled at an end of the sub passage **30** and is positioned within the housing **12** once the sub **24** is threadedly coupled to an end of the housing **12**. The check valve **36** allows for pressurized fluid to flow from the sub passage **30** into the housing **12**; however, the check valve **36** prevents pressurized fluid from flowing from the housing **12** to the sub passage **30**.

Similarly, the drive sub **106** is threadedly coupled to an opposing end of the housing **12**. The integrated claw bit **92** is movably coupled within the drive sub **106** at the opposing end of the housing **12**. The integrated claw bit **92** includes a bit passage **118** extending longitudinally therein and is in communication with one or more secondary bit passages **120**, which are in communication with an environment external to the bit **92**. The integrated claw bit **92** is capable of moving in at least an axial direction and may be capable of moving in a rotational manner as well. When the integrated claw bit **92** is in contact with the bottom of the formation or when there is a significant upward force acting upon the integrated claw bit **92**, the integrated claw bit **92** is in the dash-lined position as shown in FIG. **1**B. Conversely, when the integrated claw bit **92** is not in contact with the bottom of the formation or there is no significant upward force acting upon the integrated claw bit **92**, the integrated claw bit **92** is in the solid-lined position as shown in FIG. **1**B.

The piston **44** is a single-walled tube that includes a piston passage **70** extending substantially centrally therethrough. An orifice plug **74**, or choke valve, is positioned within the piston passage **70** at a top end of the piston **44**. The piston passage **70** is in fluid communication with piston base passage **72** formed within an opposing end of the piston **44**. The piston **44** also includes at least two pressurized fluid inlet ports **82** formed along a top portion of a sidewall of the piston **44** and extending into an interior of the piston **44**. The piston **44** further includes pressurized fluid conducting piston passageways **80** extending from the pressurized fluid inlet ports **82** to the opposing end of the piston **44**. Piston **44** further includes one or more exhaust passages **96** that extend from the piston base passage **72** to the annular chamber **97** formed between the piston **44** and the housing **12**. The exhaust passages **96** are offset from the pressurized fluid conducting piston passageways **80**. The piston **44** is movably positioned within the housing **12**. Once the piston **44** is properly assembled within the housing **12**, the top pressure fluid chamber **78**, the annular chamber **97**, and the bottom pressure fluid chamber **88** are formed. The top pressure fluid chamber **78** is formed between the one end of the piston **44** having the orifice plug **74** and the check valve **36**. The annular chamber **97** is formed between a portion of the perimeter of the piston **44** and the housing **12**. The bottom pressure fluid chamber **88** is formed between the opposing end of the piston **44** and the integrated claw bit **92**.

During operation of the conventional downhole percussion tool **10**, the tool **10** is placed in a position such that the bit **92** is urged upwardly to the position indicated by the dashed lines in FIG. **1**B and the piston **44** will be urged to the position shown by the solid lines in FIGS. **1**A and **1**B. In this position, the flow of high pressure fluid from top pressure fluid chamber **78** to annular chamber **97** is terminated since a reduced diameter portion **56** of the piston **44** is in close fitting relationship with a sleeve **62** positioned within the housing **12** and about the perimeter of a portion of the piston **44**. In this condition, pressure fluid is still communicated through pressurized fluid conducting piston passageways **80** to bottom pressure fluid chamber **88** while pressure fluid is vented from annular chamber **97** through exhaust passages **96** to the exterior of the tool **10** by way of the bit passage **118** and secondary bit passages **120**. Thus, a resultant force is exerted on the piston **44** driving it upwardly, viewing FIGS. **1**A and **1**B, until the reduced diameter portion **56***a* of the piston **44** is positioned such that the communication of high pressure fluid to pressurized fluid inlet ports **82**, pressurized fluid conducting piston passageways **80**, and bottom pressure fluid chamber **88** is cut-off. A resultant pressure fluid force acting on piston **44** will continue to drive the piston **44** upwardly, viewing FIGS. **1**A and **1**B, until the pressure fluid from bottom pressure fluid chamber **88** is able to vent through bit passage **118** and secondary bit passages **120**. This occurs when the bottom of the piston **44** is raised elevationally above the top of a tube **124**, which is positioned at least partially within bit passage **118** and extends outwardly from the top of the bit **92**. In this condition, a net resultant pressure fluid force acting on the top surface of the piston **44** is sufficient to drive the piston **44** downwardly to deliver an impact blow to the top surface of the bit **92** and the cycle just described will then repeat itself rapidly and in accordance with the design parameters of the tool **10**.

As seen in FIGS. **1**A and **1**B along with the description provided, it can be seen that the pressurized fluid is flowing into both the top pressure fluid chamber **78** and the bottom pressure fluid chamber **88** when driving the piston **44** in an upward direction. The pressure in both the top pressure fluid chamber **78** and the bottom pressure fluid chamber **88** are equal; however, since the area of the piston **44** adjacent the top pressure fluid chamber **78** is smaller than the area of the piston **44** adjacent the bottom pressure fluid chamber **88**, there is a higher force acting upon the bottom surface of the piston **44** causing the piston **44** to move in an upward direction. This becomes very inefficient because the pressures within the top pressure fluid chamber **78** and the bottom pressure fluid chamber **88** are being used against one another.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features and aspects of the invention will be best understood with reference to the following description of certain exemplary embodiments of the invention, when read in conjunction with the accompanying drawings, wherein:

FIG. **1**A is a longitudinal cross-sectional view of a portion of a conventional downhole percussion tool in accordance with the prior art;

FIG. **1**B is a longitudinal cross-sectional view of a remaining portion of the conventional downhole percussion tool of FIG. **1**A whereby FIG. **1**A is intended to be joined to FIG. **1**B along common line a-a in accordance with the prior art;

FIG. **2** is a side view of a percussion tool in accordance with an exemplary embodiment of the present invention;

FIG. **3** is a cross-sectional view of the percussion tool of FIG. **2** in accordance with an exemplary embodiment of the present invention; and

FIGS. **4**A-**4**J-**2** are cross-sectional views of the percussion tool of FIG. **3** without the bit illustrating the operation of the percussion tool in accordance with an exemplary embodiment of the present invention.

The drawings illustrate only exemplary embodiments of the invention and are therefore not to be considered limiting of its scope, as the invention may admit to other equally effective embodiments.

DETAILED DESCRIPTION OF THE INVENTION

This invention relates generally to percussion tools used in downhole drilling. More particularly, this invention relates to

an apparatus and method for controlling air flow within percussion tools, such as rotary bits, shear bits, and lighter hammer bits, used in downhole drilling. Although the description provided below is related to a percussion tool with a rotary bit, exemplary embodiments of the invention relate to any downhole percussion tool including, but not limited to, percussion tools having a shear bit, a lighter hammer bit, or other known bit used in percussion tools.

FIG. **2** is a side view of a percussion tool **200** in accordance with an exemplary embodiment of the present invention. FIG. **3** is a cross-sectional view of the percussion tool **200** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **2** and **3**, the percussion tool **200** includes a top sub **210**, a case **230**, a drive sub **250**, a mandrel **270**, and a bit **290**, which are viewable and accessible from exterior of the percussion tool **200**. The percussion tool **200** further includes a feed tube **320**, a feed tube mount **340**, a choke **360**, a piston **380**, one or more drive lugs **394**, an exhauster **365**, a split retaining ring **396**, and a check valve **302**, which are all positioned internally of the percussion tool **200**. Although certain components have been mentioned, greater or fewer components may be included in the percussion tool **200** without departing from the scope and spirit of the exemplary embodiment. Further, one or more components may be combined or separated from another mentioned component without departing from the scope and spirit of the exemplary embodiment. Once the percussion tool **200** is assembled, a top pressure fluid chamber **305** and a bottom pressure fluid chamber **308** are formed.

The top sub **210** includes a top end **311**, a bottom end **313**, a sub passage **312** extending longitudinally therein from the top end **311** towards the bottom end **313**, and a secondary sub passage **314** extending from the end of the sub passage **312** to the bottom end **313**. The top end **311** is threaded and is coupleable to a drill string (not shown) or some other down hole tool according to certain exemplary embodiments. Similarly, the bottom end **313** also is threaded and is coupled to the case **230** according to certain exemplary embodiments. The secondary sub passage **314** is in fluid communication with the sub passage **312**. The secondary sub passage **314** is larger in diameter than the sub passage **312** according to some exemplary embodiments. The secondary sub passage **314** houses a portion of the feed tube **320**, at least a portion of the feed tube mount **340**, and the choke **360** depending upon the length and positioning of the feed tube **320** according to certain exemplary embodiments. In certain other exemplary embodiments, the choke **360** is housed within the sub passage **312** or a combination of the sub passage **312** and the secondary sub passage **314**. Although not illustrated in this exemplary embodiment, the check valve **302** is optionally coupled to the top sub **210** either within the sub passage **312** or within the secondary sub passage **314** above the choke **360** and prevents the upward flow of pressurized fluid, such as air, from the top pressure fluid chamber **305** and/or the feed tube **320** to the drill string or other down hole tool positioned above the top sub **210**. Hence, in this non-illustrated exemplary embodiment, the check valve **302** allows for pressurized fluid to flow in the direction from the sub passage **312** to the case **230**; however, the check valve **302** prevents pressurized fluid from flowing in the opposite direction. In the current exemplary embodiment, however, this check valve **230** is positioned within the bit **290**, which is described in further detail below.

The case **230** is tubularly shaped and includes a top end **331**, a bottom end **333**, and a case passageway **332** extending from the top end **331** to the bottom end **333**. The case passageway **332** has a variable internal diameter along its length according to certain exemplary embodiments, however, this internal diameter is not variable in other exemplary embodiments. The top end **331** is threaded and is coupled to the bottom end **313** of the top sub **210**. Similarly, the bottom end **333** also is threaded and is coupled to the drive sub **250** according to certain exemplary embodiments. The case **230** houses at least a portion of the top sub **210**, the feed tube mount **340**, the feed tube **320**, the piston **380**, one or more drive lugs **394**, the exhauster **365**, the split retaining ring **396**, a portion of the drive sub **250**, and a portion of the mandrel **270**. Once the components of the percussion tool **200** are assembled, the top pressure fluid chamber **305** and the bottom pressure fluid chamber **308** are formed within the case **230**.

The drive sub **250** is tubularly shaped and includes a first portion **352** and a second portion **354**. The first portion **352** has an outer diameter equal to the outer diameter of the case **230**. The second portion **354** extends substantially orthogonally away from the first portion **352** and has an outer diameter less than the outer diameter of the first portion **352** and an inner diameter greater than the inner diameter of the first portion **352**. According to certain exemplary embodiments, the second portion **354** is threaded and coupled to the bottom end **333** of the case **230**. Once the drive sub **250** is assembled to the case **230**, the outer surfaces of both the first portion **352** of the drive sub **250** and the case **230** are substantially aligned. The drive sub **250** houses the one or more drive lugs **394** and a portion of the mandrel **270** and the feed tube **320**.

The mandrel **270** is a substantially solid component having a mandrel passageway **372** extending axially therethrough. The mandrel passageway **372** houses a portion of the feed tube **320** and is in fluid communication with the sub passage **312** via the feed tube **320**, which is described in greater detail below. The mandrel **270** further includes a top portion **374**, a bottom portion **378**, and a middle portion **376** extending from the top portion **374** to the bottom portion **378**. The middle portion **376** has an outer diameter less than the outer diameters of both the top portion **374** and the bottom portion **378**. The bottom portion **378** has an outer diameter equal to the outer diameter of the first portion **352** of the drive sub **250**. Further, the top portion **374** has an outer diameter less than the outer diameter of the bottom portion **378** and greater than the outer diameter of the middle portion **376**. The mandrel **270** houses a portion of the feed tube **320** and at least a portion of the exhauster **365**. Once the mandrel **270** is assembled to form the percussion tool **200**, the mandrel **270** is axially moveable with respect to both the case **230** and the drive sub **250** and a portion of the mandrel **270** is inserted and housed within the case **230**. The bottom portion **378** of the mandrel **270** is positioned adjacent to the first portion **352** of the drive sub **250** when the bit **290** is placed within the formation in contact with the bottom of the hole and with a downward force applied onto the bottom of the hole. However, the bottom portion **378** of the mandrel **270** is not positioned adjacent to the first portion **352** of the drive sub **250** when the bit **290** is placed within the formation and is not in contact with the bottom of the hole. The mandrel passageway **372** has a larger diameter at the bottom portion **378** of the mandrel **270** and is configured to receive a portion of the bit **290** therein according to certain exemplary embodiments. In certain of these exemplary embodiments, the lower portion of the mandrel passageway **372** is threaded and engages with a portion of the bit **290**. However, in alternative exemplary embodiments, the bit **290** and the mandrel **270** are formed as an integral component, such as when the percussion tool includes a hammer bit.

Bit **290** is a roller cone bit that is coupled to the mandrel **270** within the lower portion of the mandrel passageway **372** according to certain exemplary embodiments. The bit **290** is threadedly engaged to the mandrel **270** according to some exemplary embodiments. Although the bit **290** is illustrated as a roller cone bit in certain exemplary embodiments, the bit **290** is a different type of bit, such as a polycrystalline diamond cutter (PDC) bit, or other type of drag bit or fixed cutter bit. Alternatively, in other exemplary embodiments, the bit **290** is integrally formed with the mandrel **270**, such as a hammer bit, as a single component. Bit **290** includes a bit passageway **392** extending therein and in fluid communication with the mandrel passageway **372**. The bit passageway **392** communicates pressurized fluid, such as air, from the mandrel passageway **372** to an environment external of the bit **290**. Further, according to certain exemplary embodiments, the check valve **302** is coupled within the bit passageway **392** of the bit **290**. The check valve **302** is designed to allow flow from the mandrel passageway **372** to the environment external to the bit **290**; however, the check valve **302** prevents flow in the reverse direction. As previously mentioned, according to some alternative exemplary embodiments, this check valve **302** is positioned upstream, or vertically above, the choke **360**.

As previously mentioned, the percussion tool **200** further includes the feed tube **320**, the feed tube mount **340**, the choke **360**, the piston **380**, one or more drive lugs **394**, the exhauster **365**, and the split retaining ring **396**. According to certain exemplary embodiments, the feed tube **320** is a double-wall feed tube and is tubular in shape. The feed tube **320** includes a top end **321**, a bottom end **322**, an upper portion **323**, and a lower portion **324**. The feed tube **320** also includes an inner wall **398** and an outer wall **399**. The upper portion **323** extends from the top end **321** towards the bottom end **322** and the lower portion **324** extends from the upper portion **323** to the bottom end **322**. According to certain exemplary embodiments, the upper portion **323** has a greater outer diameter than the lower portion **324**. The feed tube **320** includes a central feed tube channel **325** extending from the top end **321** to the bottom end **322** and is defined by the inner wall **398**. The central feed tube channel **325** communicates pressurized fluid from the sub passage **312** to the mandrel passageway **372**. The feed tube **320** also includes an outer feed tube channel **326**, which extends from the top end **321** towards the lower portion **324**, but remains within the upper portion **323** according to certain exemplary embodiments. The outer feed tube channel **326** is defined by the outer wall **399** and the inner wall **398** and is positioned therebetween. However, in other exemplary embodiments, the outer feed tube channel **326** extends into the lower portion **324** but not through the feed tube **320**. The outer feed tube channel **326** circumferentially surrounds a portion of the length of the central feed tube channel **325**; however, in other exemplary embodiments, the outer feed tube channel **326** does not circumferentially surround a portion of the central feed tube channel **325**. For example, the outer feed tube channel **326** may be a single channel extending from the top end **321** or may be several discrete channels extending from the top end **321**. Additionally, the feed tube **320** includes one or more first openings **327** and one or more second openings **328** positioned about the perimeter of the upper portion **323** through the outer wall **399**. However, in other exemplary embodiments, some or all of these openings **327**, **328** are positioned about the perimeter of the lower portion **324** when the outer feed tube channel **326** extends into the lower portion **324**. The first openings **327** communicate pressurized fluid from within the outer feed tube channel **326** to the bottom pressure fluid chamber **308** through an interior of the piston **380**, while the second openings **328** communicate pressurized fluid from within the outer feed tube channel **326** to the top pressure fluid chamber **305** via the interior of the piston **380**. According to some exemplary embodiments, the first openings **327** are radially aligned with one another at substantially the same elevation; however, in other exemplary embodiments, one or more first openings **327** are not radially aligned with one another at the same elevation. Similarly, according to some exemplary embodiments, the second openings **328** are radially aligned with one another at substantially the same elevation; however, in other exemplary embodiments, one or more second openings **328** are not radially aligned with one another at the same elevation. Yet, in other exemplary alternative exemplary embodiments, there are only one or more first openings **327** and no second openings **328** as the first openings are configured to convey pressurized fluid either to the bottom pressure fluid chamber **308** or to the top pressure fluid chamber **305** depending upon the elevational positioning of the piston **380**. In other exemplary embodiments, the first openings **327** communicate pressurized fluid from within the outer feed tube channel **326** to the top pressure fluid chamber **305** through an interior of the piston **380**, while the second openings **328** communicate pressurized fluid from within the outer feed tube channel **326** to the bottom pressure fluid chamber **308** via the interior of the piston **380**.

The feed tube **320** extends from within a portion of the top sub **210** to within a portion of the mandrel **270** and facilitates the communication of pressurized fluid from the sub passage **312** of the top sub **210** to the mandrel passageway **372** of the mandrel **270** and also facilitates the communication of pressurized fluid from the sub passage **312** of the top sub **210** to either to the bottom pressure fluid chamber **308** or to the top pressure fluid chamber **305** depending upon the elevational positioning of the piston **380**. According to some exemplary embodiments, the top end **321** of the feed tube **320** extends into the sub passage **312**. According to some exemplary embodiments, the outer diameters of the top end **321** of the feed tube **320** and the sub passage **312** are substantially the same such that the top end **321** frictionally fits within the sub passage **312**. The feed tube **320** is surrounded by a portion of the top sub **210**, the casing **230**, a portion of the drive sub **250**, a portion of the mandrel **270**, the feed tube mount **340**, the piston **380**, the one or more drive lugs **394**, the exhauster **365**, and the split retaining ring **396**. According to certain exemplary embodiments, the feed tube **320** is fixedly coupled within the interior of the percussion tool **200** using at least one of the feed tube mount **340** and/or the exhauster **365**. For example, in one or more exemplary embodiments, the feed tube **320** frictionally fits within the feed tube mount **340** and/or the exhauster **365**.

The feed tube mount **340** is annularly shaped with a feed tube mount passageway **342** extending longitudinally therethrough according to certain exemplary embodiments. The feed tube mount **340** is positioned within the secondary sub passage **314** according to some exemplary embodiments, but can be positioned elsewhere, such as within the top pressure fluid chamber **305** in other exemplary embodiments. The feed tube mount passageway **342** receives at least a portion of the feed tube **320** and may assist in mounting the feed tube **320** within the percussion tool **200**. According to certain exemplary embodiments, the feed tube **320** extends entirely through the feed tube mount **340**.

The choke **360** also is annularly shaped and forms a plug that fits into the central feed tube channel **325** at the top end **321** of the feed tube **320**. The choke **360** includes a choke passageway **362** formed longitudinally therethrough. The dimension, or diameter, of this choke passageway **362** limits the amount of pressurized fluid flowing into the central feed tube channel **325** from the sub passage **312**. The pressurized fluid generally flows from the sub passage **312** into the outer feed tube channel **326** and then into either the bottom pressure fluid chamber **308** or to the top pressure fluid chamber **305** depending upon the elevational positioning of the piston **380**. However, the excess pressurized fluid flows into the central feed tube channel **325** through the choke **360**. The choke **360** is replaceable depending upon the desired restriction, which determines the amount of pressurized fluid that flows into the central feed tube channel **325** through the choke **360**. For example, less pressurized fluid flows into the central feed tube channel **325** through the choke **360** when the dimension, or diameter, of the choke passageway **362** is small when compared to when the dimension, or diameter, of the choke passageway **362** is larger. The replacement of the choke **360** is fairly simple and does not require several components of the percussion tool **200** to be dismantled. The top sub **210**, along with the remaining components of the percussion tool **200** positioned below the top sub **210**, is threadedly removed, or disengaged, from the drill string, or other down hole tool, that it is coupled to. Once the top sub **210** is disengaged, an operator is able to remove the choke **360** by accessing it through the sub passage **312** from the top end **311**. Once the operator removes the choke **360**, the operator is able to install a different choke of a different size, or the same size if choke **360** has been damaged, depending upon the operating requirements through the same sub passage **312** from the top end **311**. Once the choke **360** has been replaced, the top sub **210**, along with the remaining attached components, are threadedly coupled, or re-engaged, to the drill string, or other down hole tool, that it is to be coupled to.

Piston **380** is annularly shaped and includes a top end **381**, a bottom end **382**, an exterior surface **383**, and an interior surface **384** that defines a piston passageway **385** extending longitudinally through the piston **380**. The piston **380** further includes at least one first pressurized fluid conduit **386** that extends from the interior surface **384** to the top end **381** and at least one second pressurized fluid conduit **387** that extends from the interior surface **384** to the bottom end **382**. Further, the piston **380** includes at least one top exhaust conduit **430** (FIG. **4B-2**) that extends from the top end **381** to a lower portion of the interior surface **384** such that the top exhaust conduit **430** (FIG. **4B-2**) can communicate pressurized fluid from the top pressure fluid chamber **305** to the exhauster **365** when the at least one second pressurized fluid conduit **387** communicates pressurized fluid to the bottom pressure fluid chamber **308**. The piston **380** is positioned within the case passageway **332** such that the interior surface **384** is positioned slidably and in contact with the feed tube **320** and the exterior surface **383** is positioned slidably and in contact with the casing **230**. Once the piston **380** is slidably positioned within the case passageway **332**, the top pressure fluid chamber **305** is formed within the case passageway **332** adjacently above the top end **381** and the bottom pressure fluid chamber **308** is formed within the case passageway **332** adjacently below the bottom end **382**. As the piston slidably moves upward towards the top sub **210**, the volume of the top pressure fluid chamber **305** decreases while the volume of the bottom pressure fluid chamber **308** increases. Conversely, as the piston **380** slidably moves downward towards the mandrel **270**, the volume of the top pressure fluid chamber **305** increases while the volume of the bottom pressure fluid chamber **308** decreases. The piston **380** is used to deliver a downward force onto the mandrel **270** when the bottom end **382** makes downward contact with the mandrel **270**. The piston **380** is forced back up and then cycles down again to make contact with the mandrel **270**. This cycling of the piston **380** continues until the flow of pressurized fluid through the outer feed tube channel **326** is stopped. The details of this piston **380** operation is provided below in conjunction with FIGS. **4**A-J in accordance with one or more exemplary embodiments.

One or more drive lugs **394** are annularly shaped, stacked on top of one another, and positioned between and in contact with the second portion **354** of the drive sub **250** and the middle portion **376** of the mandrel **270**. Each drive lug **394** includes a drive lug passageway **395** that extends longitudinally therethrough and receives a portion of the mandrel **270** therein. Specifically, once the drive lugs **394** and the mandrel **270** are properly installed, the middle portion **376** of the mandrel **270** slidably engages with the one or more drive lugs **394** through the drive lug passageway **395**. When an upward force is placed onto the bottom of the bit **290**, the mandrel **270** slidably moves toward the top sub **210** such that the bottom portion **378** of the mandrel **270** and the drive sub **250** are adjacent and/or in contact with one another. Conversely, when an upward force is not placed onto the bottom of the bit **290**, the mandrel **270** slidably moves away the top sub **210** such that the bottom portion **378** of the mandrel **270** and the drive sub **250** are not adjacent and/or not in contact with one another. According to the exemplary embodiment, three drive lugs **394** are shown; however, greater or fewer drive lugs **394** are used in other exemplary embodiments.

The split retaining ring **396** also is annularly shaped, stacked on top of one of the drive lugs **394** and the second portion **354** of the drive sub **250**, and positioned between and in contact with the lower portion of the case **230** and the middle portion **376** of the mandrel **270** The split retaining ring **396** includes a split retaining ring passageway **397** that extends longitudinally therethrough and receives a portion of the mandrel **270** therein. Specifically, once the split retaining ring **396** and the mandrel **270** are properly installed, the middle portion **376** of the mandrel **270** slidably engages with the split retaining ring **396** through the split retaining ring passageway **397**. When an upward force is placed onto the bottom of the bit **290**, the mandrel **270** slidably moves toward the top sub **210** such that the top portion **374** of the mandrel **270** and the split retaining ring **396** are not adjacent and/or in contact with one another. Conversely, when an upward force is not placed onto the bottom of the bit **290**, the mandrel **270** slidably moves away the top sub **210** such that the top portion **374** of the mandrel **270** and the split retaining ring **396** are adjacent and/or in contact with one another. The split retaining ring **396** prevents the mandrel **270** and the bit **290** from disengaging from the remaining components of the percussion tool **200**, such as the casing **230**. According to the exemplary embodiment, a single split retaining ring **396** is shown; however, greater number of split retaining rings **396** are used in other exemplary embodiments.

The exhauster **365** also is annularly shaped and is doubled-walled in accordance with some exemplary embodiments. The exhauster **365** includes an inner wall **366** and an outer wall **367**. The inner wall **366** is tubularly shaped and defines an exhauster inner passageway **368** that extends longitudinally therethrough. The exhauster inner passageway **368** receives a portion of the lower portion **324** of the feed tube **320**, which extends through the entire exhauster inner passageway **368**. According to certain exemplary embodiments, the inner wall **366** provide some support to the feed tube **320**. The outer wall **367** also is tubularly shaped and surrounds the inner wall **366**. The outer wall **367** and the inner wall **366** collectively define an exhauster outer passageway **369** that extends longitudinally through the exhauster **365**. The exhauster outer passageway **369** provides a pathway to exhaust pressurized fluid from the top fluid pressure chamber **305**, through the piston **380**, and into mandrel passageway **372** so that the pressurized fluid may exit to the external environment as the piston **380** moves upwardly towards the top sub **210**. The exhauster **365** is positioned around a portion of the feed tube **320** and located between the feed tube **320** and a portion of the mandrel **270** and a portion of the piston **380** when the piston **380** is at its lower position. When the piston moves to its lower position, i.e. towards the mandrel **270**, a portion of the exhauster **365** slides into the piston passageway **385**, thereby preventing the exhaust of pressurized fluid from the bottom fluid pressure chamber **308**.

FIGS. **4**A-**4**J-**2** are cross-sectional views of the percussion tool **200** without the bit **290** (FIG. **2**) illustrating the operation of the percussion tool **200** in accordance with an exemplary embodiment of the present invention. Specifically, FIG. **4**A is a cross-sectional view of the percussion tool **200** when no upward force is exerted on the mandrel **270** in accordance with an exemplary embodiment of the present invention. Referring to FIG. **4**A and as previously mentioned, the bottom portion **378** of the mandrel **270** is not positioned adjacent to the first portion **352** of the drive sub **250** when the bit **290** (FIG. **2**) is placed within the formation and is not in contact with the bottom of the hole, for example, when an upward force is not exerted on the mandrel **270**. Further, the top portion **374** of the mandrel **270** is in contact with the split retaining ring **396** and is prevented from being disengaged from the remaining components of the percussion tool **200**. Hence, the mandrel **270** remains housed within at least a portion of the casing **230**. Additionally, the piston **380** is positioned adjacently and in contact with the top portion **374** of the mandrel **270**. However, once an upward force is exerted on the bottom of the mandrel **270**, such as when the bit **290** (FIG. **2**) is in contact with the bottom of the hole during drilling and as shown in each of FIGS. **4**B-**1**-**4**J-**2**, the bottom portion **378** of the mandrel **270** is positioned adjacently and in contact with the first portion **352** of the drive sub **250**.

For convenience purposes, it is assumed that an upward force is exerted on the bottom of the mandrel **270** in each of FIGS. **4**B-**1**-**4**J-**2** and therefore is not reiterated in the descriptions for each of those figures. Further, the non-illustration of the bit **290** (FIG. **2**) in each of FIGS. **4**B-**1**-**4**J-**2** is not reiterated in the description for each of those figures. Either a bit, such as bit **290** (FIG. **2**) is coupled to the mandrel **270** or an integrated bit, such as a hammer, is formed with the mandrel **270**.

FIG. **4**B-**1** is a cross-sectional view of the percussion tool **200** with the piston **380** in the down position **410** and showing the positioning of the at least one first pressurized fluid conduit **386** and the at least one second pressurized fluid conduit **387** in accordance with an exemplary embodiment of the present invention. FIG. **4**B-**2** is a cross-sectional view of the percussion tool **200** with the piston **380** in the down position **410** and showing the positioning of the at least one top exhaust conduit **430** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **4**B-**1** and **4**B-**2**, the piston **380** is positioned in the down position **410** and facilitates forming the top pressure fluid chamber **305** above it and the bottom pressure fluid chamber **308** below it, where the bottom pressure fluid chamber **308** is smaller in volume than the top pressure fluid chamber **305**. At this down position **410**, the second pressurized fluid conduits **387** within the piston **380** are in fluid communication with at least one respective first opening **327** of the feed tube **320** and hence is able to communicate pressurize fluid from the outer feed tube channel **326** to the bottom pressure fluid chamber **308**. However, at this down position **410**, the first pressurized fluid conduits **386** within the piston **380** are not in fluid communication with any of the second openings **328** of the feed tube **320** and hence is not able to communicate pressurize fluid from the outer feed tube channel **326** to the top pressure fluid chamber **305**. Thus, only the bottom pressure fluid chamber **308** is filled with pressurized fluid while the top pressure fluid chamber **305** is not, when the piston **380** is at this down position **410**. As the bottom pressure fluid chamber **308** is filled and the pressure therein increases, the piston **380** commences rising, thereby decreasing the volume of the top pressure fluid chamber **305** and increasing the volume of the bottom pressure fluid chamber **308**. The pressurized fluid within the bottom pressure fluid chamber **308** does not exhaust through the exhauster **365** when the piston **380** is at this down position **410**. As the volume on the top pressure fluid chamber **305** decreases, the fluid therein is exhausted to the outside environment through the at least one top exhaust conduit **430**. This fluid proceeds from the top pressure fluid chamber **305**, into the at least one top exhaust conduit **430**, through the exhauster **365**, through the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). The excess pressurized fluid flowing from the sub passage **312**, which is not used for filling the bottom pressure fluid chamber **308**, flows into the central feed tube channel **325** of the feed tube **320** via the choke **360**, then through the exhauster **365** into the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As seen, the pressurized fluid enters only the bottom pressure fluid chamber **308** and therefore is not used to counteract, or work against, itself when being used to move the piston **380**.

FIG. **4C-1** is a cross-sectional view of the percussion tool **200** with the piston **380** in a first intermediate upward moving position **411** and showing the positioning of the at least one first pressurized fluid conduit **386** and the at least one second pressurized fluid conduit **387** in accordance with an exemplary embodiment of the present invention. FIG. **4C-2** is a cross-sectional view of the percussion tool **200** with the piston **380** in the first intermediate upward moving position **411** and showing the positioning of the at least one top exhaust conduit **430** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **4C-1** and **4C-2**, the piston **380** is positioned in the first intermediate upward moving position **411** and facilitates forming the top pressure fluid chamber **305** above it and the bottom pressure fluid chamber **308** below it. The bottom pressure fluid chamber **308** has increased in volume and the top pressure fluid chamber **305** has decreased in volume when compared to when the piston **380** was in the down position **410** (FIG. **4B-1**). At this first intermediate upward moving position **411**, the second pressurized fluid conduits **387** within the piston **380** are still in fluid communication with at least one respective first opening **327** of the feed tube **320** and hence still communicates pressurize fluid from the outer feed tube channel **326** to the bottom pressure fluid chamber **308**. However, at this first intermediate upward moving position **411**, the first pressurized fluid conduits **386** within the piston **380** are not in fluid communication with any of the second openings **328** of the feed tube **320** and hence is not able to communicate pressurize fluid from the outer feed tube channel **326** to the top pressure fluid chamber **305**. Thus, only the bottom pressure fluid chamber **308** is filled with pressurized fluid while the top pressure fluid chamber **305** is not, when the piston **380** is at this first intermediate upward moving position **411**. As the bottom pressure fluid chamber **308** continues to be filled and the pressure therein increases, the piston **380** continues rising, thereby further decreasing the volume of the top pressure fluid chamber **305** and further increasing the volume of the bottom pressure fluid chamber **308**. The pressurized fluid within the bottom pressure fluid chamber **308** still does not exhaust through the exhauster **365** when the piston **380** is at this first intermediate upward moving position **411**. As the volume on the top pressure fluid chamber **305** continues to decrease, the fluid therein continues to be exhausted to the outside environment through the at least one top exhaust conduit **430**. This fluid proceeds from the top pressure fluid chamber **305**, into the at least one top exhaust conduit **430**, through the exhauster **365**, through the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). The excess pressurized fluid flowing from the sub passage **312**, which is not used for filling the bottom pressure fluid chamber **308**, flows into the central feed tube channel **325** of the feed tube **320** via the choke **360**, then through the exhauster **365** into the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As seen, the pressurized fluid still enters only the bottom pressure fluid chamber **308** and therefore is not used to counteract, or work against, itself when being used to move the piston **380**.

FIG. **4D-1** is a cross-sectional view of the percussion tool **200** with the piston **380** in a second intermediate upward moving position **412** and showing the positioning of the at least one first pressurized fluid conduit **386** and the at least one second pressurized fluid conduit **387** in accordance with an exemplary embodiment of the present invention. FIG. **4D-2** is a cross-sectional view of the percussion tool **200** with the piston **380** in the second intermediate upward moving position **412** and showing the positioning of the at least one top exhaust conduit **430** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **4D-1** and **4D-2**, the piston **380** is positioned in the second intermediate upward moving position **412** and facilitates forming the top pressure fluid chamber **305** above it and the bottom pressure fluid chamber **308** below it. The bottom pressure fluid chamber **308** has further increased in volume and the top pressure fluid chamber **305** has further decreased in volume when compared to when the piston **380** was in the first intermediate upward moving position **411** (FIG. **4C-1**). At this second intermediate upward moving position **412**, the second pressurized fluid conduits **387** within the piston **380** are no longer in fluid communication with the first openings **327** of the feed tube **320** and hence do not communicate pressurized fluid from the outer feed tube channel **326** to the bottom pressure fluid chamber **308**. Similarly, at this second intermediate upward moving position **412**, the first pressurized fluid conduits **386** within the piston **380** also are not in fluid communication with any of the second openings **328** of the feed tube **320** and hence are not able to communicate pressurized fluid from the outer feed tube channel **326** to the top pressure fluid chamber **305**. Thus, neither the bottom pressure fluid chamber **308** nor the top pressure fluid chamber **305** is filled with pressurized fluid, when the piston **380** is at this second intermediate upward moving position **412**. However, the piston **380** continues moving in an upward direction from the forces previously applied to the bottom of the piston. Hence, as the piston **380** continues rising, the volume of the top pressure fluid chamber **305** continues to further decrease, while the volume of the bottom pressure fluid chamber **308** continues to further increase. The pressurized fluid within the bottom pressure fluid chamber **308** still does not exhaust through the exhauster **365** when the piston **380** is at this second intermediate upward moving position **412**. Similarly, the fluid within the top pressure fluid chamber **305** no longer continues to exhaust through the exhauster **365** since the top exhaust conduits **430** are not in fluid communication with the exhauster **365**. The excess pressurized fluid flowing from the sub passage **312**, which is substantially all the pressurized fluid therein, flows into the central feed tube channel **325** of the feed tube **320** via the choke **360**, then through the exhauster **365** into the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As seen, the pressurized fluid does not enter any of the bottom pressure fluid chamber **308** or the top pressure fluid chamber **305**, and therefore is not used to counteract, or work against, itself when being used to move the piston **380**.

FIG. **4E-1** is a cross-sectional view of the percussion tool **200** with the piston **380** in a third intermediate upward moving position **413** and showing the positioning of the at least one first pressurized fluid conduit **386** and the at least one second pressurized fluid conduit **387** in accordance with an exemplary embodiment of the present invention. FIG. **4E-2** is a cross-sectional view of the percussion tool **200** with the piston **380** in the third intermediate upward moving position **413** and showing the positioning of the at least one top exhaust conduit **430** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **4**E-**1** and **4**E-**2**, the piston **380** is positioned in the third intermediate upward moving position **413** and facilitates forming the top pressure fluid chamber **305** above it and the bottom pressure fluid chamber **308** below it. The bottom pressure fluid chamber **308** has increased in volume and the top pressure fluid chamber **305** has decreased in volume when compared to when the piston **380** was in the second intermediate upward moving position **412** (FIG. **4**D-**1**). At this third intermediate upward moving position **413**, the first pressurized fluid conduits **386** within the piston **380** are now in fluid communication with at least one respective second opening **328** of the feed tube **320** and hence communicates pressurized fluid from the outer feed tube channel **326** to the top pressure fluid chamber **305**. However, at this third intermediate upward moving position **413**, the second pressurized fluid conduits **387** within the piston **380** are not in fluid communication with any of the first openings **327** of the feed tube **320** and hence are not able to communicate pressurized fluid from the outer feed tube channel **326** to the bottom pressure fluid chamber **308**. Thus, now only the top pressure fluid chamber **305** is filled with pressurized fluid while the bottom pressure fluid chamber **308** is not, when the piston **380** is at this third intermediate upward moving position **413**. As the top pressure fluid chamber **305** is now filled with pressurized fluid and the pressure therein increases, the piston **380** continues rising but starts slowing down, thereby further decreasing the volume of the top pressure fluid chamber **305** and further increasing the volume of the bottom pressure fluid chamber **308**. The pressurized fluid within the bottom pressure fluid chamber **308** now exhausts through the exhauster **365** when the piston **380** is at this third intermediate upward moving position **413**. This fluid proceeds from the bottom pressure fluid chamber **308**, through the exhauster **365**, through the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As the volume in the top pressure fluid chamber **305** continues to decrease, the fluid therein is pressurized more since the fluid therein is not exhausted through the exhauster **365**. The at least one top exhaust conduit **430** is no longer fluidly communicable with the exhauster **365**. This pressurized fluid within the top pressure fluid chamber **305** causes the piston **380** to slow down in its upward movement. The excess pressurized fluid flowing from the sub passage **312**, which is not used for filling the top pressure fluid chamber **305**, flows into the central feed tube channel **325** of the feed tube **320** via the choke **360**, then through the exhauster **365** into the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As seen, the pressurized fluid now enters only the top pressure fluid chamber **305** and therefore is not used to counteract, or work against, itself when being used to slow the movement of the piston **380**.

FIG. **4F-1** is a cross-sectional view of the percussion tool **200** with the piston **380** in an up position **414** and showing the positioning of the at least one first pressurized fluid conduit **386** and the at least one second pressurized fluid conduit **387** in accordance with an exemplary embodiment of the present invention. FIG. **4F-2** is a cross-sectional view of the percussion tool **200** with the piston **380** in the up position **414** and showing the positioning of the at least one top exhaust conduit **430** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **4F-1** and **4F-2**, the piston **380** is positioned in the up position **414** and facilitates forming the top pressure fluid chamber **305** above it and the bottom pressure fluid chamber **308** below it. The bottom pressure fluid chamber **308** has increased in volume and the top pressure fluid chamber **305** has decreased in volume when compared to when the piston **380** was in the third intermediate upward moving position **413** (FIG. **4**E-**1**). At this up position **414**, the first pressurized fluid conduits **386** within the piston **380** are still in fluid communication with at least one respective second opening **328** of the feed tube **320** and hence communicates pressurized fluid from the outer feed tube channel **326** to the top pressure fluid chamber **305**. However, at this up position **414**, the second pressurized fluid conduits **387** within the piston **380** are not in fluid communication with any of the first openings **327** of the feed tube **320** and hence are not able to communicate pressurized fluid from the outer feed tube channel **326** to the bottom pressure fluid chamber **308**. Thus, now only the top pressure fluid chamber **305** is filled with pressurized fluid while the bottom pressure fluid chamber **308** is not, when the piston **380** is at this up position **414**. At this up position **414**, the piston **380** is at its highest elevational position and the top pressure fluid chamber **305** is at its smallest volume. As the top pressure fluid chamber **305** continues to be filled with pressurized fluid and the pressure therein increases, the piston **380** will start falling, thereby eventually increasing the volume of the top pressure fluid chamber **305** and decreasing the volume of the bottom pressure fluid chamber **308**. The pressurized fluid within the bottom pressure fluid chamber **308** continues to be exhausted through the exhauster **365** when the piston **380** is at this up position **414**. This fluid proceeds from the bottom pressure fluid chamber **308**, through the exhauster **365**, through the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As the volume in the top pressure fluid chamber **305** is relatively constant, the fluid therein is pressurized more as more pressurized fluid enters the top pressure fluid chamber **305** and since the fluid therein is not exhausted through the exhauster **365**. The at least one top exhaust conduit **430** is still not fluidly communicable with the exhauster **365**. This pressurized fluid within the top pressure fluid chamber **305** causes the piston **380** to stop its upward movement. The excess pressurized fluid flowing from the sub passage **312**, which is not used for filling the top pressure fluid chamber **305**, flows into the central feed tube channel **325** of the feed tube **320** via the choke **360**, then through the exhauster **365** into the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As seen, the pressurized fluid now enters only the top pressure fluid chamber **305** and therefore is not used to counteract, or work against, itself when being used to stop the movement of the piston **380**.

FIG. **4G-1** is a cross-sectional view of the percussion tool **200** with the piston **380** in a first intermediate downward moving position **415** and showing the positioning of the at least one first pressurized fluid conduit **386** and the at least one second pressurized fluid conduit **387** in accordance with an exemplary embodiment of the present invention. FIG. **4G-2** is a cross-sectional view of the percussion tool **200** with the piston **380** in the first intermediate downward moving position **415** and showing the positioning of the at least one top exhaust conduit **430** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **4G-1** and **4G-2**, the piston **380** is positioned in the first intermediate downward moving position **415** and facilitates forming the top pressure fluid chamber **305** above it and the bottom pressure fluid chamber **308** below it. The bottom pressure fluid chamber **308** has decreased in volume and the top pressure fluid chamber **305** has increased in volume when compared to when the piston **380** was in the up position **414** (FIG. **4F-1**). At this first intermediate downward moving position **415**, the first pressurized fluid conduits **386** within the piston **380** are still in fluid communication with at least one respective second opening **328** of the feed tube **320** and hence continue to communicate pressurized fluid from the outer feed tube channel **326** to the top pressure fluid chamber **305**. However, at this first intermediate downward moving position **415**, the second pressurized fluid conduits **387** within the piston **380** are still not in fluid communication with any of the first openings **327** of the feed tube **320** and hence still does not communicate pressurized fluid from the outer feed tube channel **326** to the bottom pressure fluid chamber **308**. Thus, only the top pressure fluid chamber **305** is filled with pressurized fluid while the bottom pressure fluid chamber **308** is not, when the piston **380** is at this first intermediate downward moving position **415**. As the top pressure fluid chamber **305** continues to be filled and the pressure therein increases, the piston **380** continues falling, thereby further decreasing the volume of the bottom pressure fluid chamber **308** and further increasing the volume of the top pressure fluid chamber **305**. The pressurized fluid within the top pressure fluid chamber **305** still does not exhaust through the exhauster **365** when the piston **380** is at this first intermediate downward moving position **415**. As the volume in the bottom pressure fluid chamber **308** continues to decrease, the fluid therein continues to be exhausted to the outside environment through the exhauster **365** when the piston **380** is at this first intermediate downward moving position **415**. This fluid proceeds from the bottom pressure fluid chamber **308**, through the exhauster **365**, through the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As the pressurized fluid enters the top pressure fluid chamber **305** and the pressurized fluid within the top pressure fluid chamber **305** is not exhausted, the fluid therein forces the piston **380** to move further downward. The at least one top exhaust conduit **430** is still not fluidly communicable with the exhauster **365**. The excess pressurized fluid flowing from the sub passage **312**, which is not used for filling the top pressure fluid chamber **305**, flows into the central feed tube channel **325** of the feed tube **320** via the choke **360**, then through the exhauster **365** into the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As seen, the pressurized fluid still enters only the top pressure fluid chamber **305** and therefore is not used to counteract, or work against, itself when being used to move the piston **380**.

FIG. **4H-1** is a cross-sectional view of the percussion tool **200** with the piston **380** in a second intermediate downward moving position **416** and showing the positioning of the at least one first pressurized fluid conduit **386** and the at least one second pressurized fluid conduit **387** in accordance with an exemplary embodiment of the present invention. FIG. **4H-2** is a cross-sectional view of the percussion tool **200** with the piston **380** in the second intermediate downward moving position **416** and showing the positioning of the at least one top exhaust conduit **430** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **4H-1** and **4H-2**, the piston **380** is positioned in the second intermediate downward moving position **416** and facilitates forming the top pressure fluid chamber **305** above it and the bottom pressure fluid chamber **308** below it. The top pressure fluid chamber **305** has further increased in volume and the bottom pressure fluid chamber **308** has further decreased in volume when compared to when the piston **380** was in the first intermediate downward moving position **415** (FIG. **4G-1**). At this second intermediate downward moving position **416**, the first pressurized fluid conduits **386** within the piston **380** are no longer in fluid communication with the second openings **328** of the feed tube **320** and hence do not communicate pressurized fluid from the outer feed tube channel **326** to the top pressure fluid chamber **305**. Similarly, at this second intermediate downward moving position **416**, the second pressurized fluid conduits **387** within the piston **380** also are not in fluid communication with any of the first openings **327** of the feed tube **320** and hence are not able to communicate pressurized fluid from the outer feed tube channel **326** to the bottom pressure fluid chamber **308**. Thus, neither the top pressure fluid chamber **305** nor the bottom pressure fluid chamber **308** is filled with pressurized fluid, when the piston **380** is at this second intermediate downward moving position **416**. However, the piston **380** continues moving in a downward direction from the forces previously applied to the top of the piston **380**. Hence, as the piston **380** continues falling, the volume of the bottom pressure fluid chamber **308** continues to further decrease, while the volume of the top pressure fluid chamber **305** continues to further increase. The pressurized fluid within the top pressure fluid chamber **305** still does not exhaust through the exhauster **365** when the piston **380** is at this second intermediate downward moving position **416** since the top exhaust conduits **430** are not in fluid communication with the exhauster **365**. Similarly, the fluid within the bottom pressure fluid chamber **308** no longer continues to exhaust through the exhauster **365** since the bottom pressure fluid chamber **308** is not in fluid communication with the exhauster **365**. The excess pressurized fluid flowing from the sub passage **312**, which is substantially all the pressurized fluid therein, flows into the central feed tube channel **325** of the feed tube **320** via the choke **360**, then through the exhauster **365** into the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As seen, the pressurized fluid does not enter any of the top pressure fluid chamber **305** or the bottom pressure fluid chamber **308**, and therefore is not used to counteract, or work against, itself when being used to move the piston **380**.

FIG. **4I-1** is a cross-sectional view of the percussion tool **200** with the piston **380** in a third intermediate downward moving position **417** and showing the positioning of the at least one first pressurized fluid conduit **386** and the at least one second pressurized fluid conduit **387** in accordance with an exemplary embodiment of the present invention. FIG. **4I-2** is a cross-sectional view of the percussion tool **200** with the piston **380** in the third intermediate downward moving position **417** and showing the positioning of the at least one top exhaust conduit **430** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **4I-1** and **4I-2**, the piston **380** is positioned in the third intermediate downward moving position **417** and facilitates forming the top pressure fluid chamber **305** above it and the bottom pressure fluid chamber **308** below it. The top pressure fluid chamber **305** has increased in volume and the bottom pressure fluid chamber **308** has decreased in volume when compared to when the piston **380** was in the second intermediate downward moving position **416** (FIG. **4H-1**). At this third intermediate downward moving position **417**, the second pressurized fluid conduits **387** within the piston **380** are now in fluid communication with at least one respective first opening **327** of the feed tube **320** and hence communicates pressurized fluid from the outer feed tube channel **326** to the bottom pressure fluid chamber **308**. However, at this third intermediate downward moving position **417**, the first pressurized fluid conduits **386** within the piston **380** are not in fluid communication with any of the second openings **328** of the feed tube **320** and hence are not able to communicate pressurized fluid from the outer feed tube channel **326** to the top pressure fluid chamber **305**. Thus, now only the bottom pressure fluid chamber **308** is filled with pressurized fluid while the top pressure fluid chamber **305** is not, when the piston **380** is at this third intermediate downward moving position **417**. As the bottom pressure fluid chamber **308** is now filled with pressurized fluid and the pressure therein increases, the piston **380** continues falling but starts slowing down, thereby further decreasing the volume of the bottom pressure fluid chamber **308** and further increasing the volume of the top pressure fluid chamber **305**. The pressurized fluid within the top pressure fluid chamber **305** now exhausts through the exhauster **365** when the piston **380** is at this third intermediate downward moving position **417**. This fluid proceeds from the top pressure fluid chamber **305**, through the at least one top exhaust conduit **430**, through the exhauster **365**, through the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As the volume in the bottom pressure fluid chamber **308** continues to decrease, the fluid therein is pressurized more since the fluid therein is not exhausted through the exhauster **365**. The bottom pressure fluid chamber **308** is no longer fluidly communicable with the exhauster **365**. This pressurized fluid within the bottom pressure fluid chamber **308** causes the piston **380** to slow down in its downward movement. The excess pressurized fluid flowing from the sub passage **312**, which is not used for filling the bottom pressure fluid chamber **308**, flows into the central feed tube channel **325** of the feed tube **320** via the choke **360**, then through the exhauster **365** into the mandrel passageway **372**, and out the bit **290** (FIG. **2**) through the check valve **302** (FIG. **3**), if positioned within the bit **290** (FIG. **2**), and the bit passageway **392** (FIG. **3**). As seen, the pressurized fluid now enters only the bottom pressure fluid chamber **308** and therefore is not used to counteract, or work against, itself when being used to slow the movement of the piston **380**.

FIG. **4J-1** is a cross-sectional view of the percussion tool **200** with the piston **380** in the down position **410** and showing the positioning of the at least one first pressurized fluid conduit **386** and the at least one second pressurized fluid conduit **387** in accordance with an exemplary embodiment of the present invention. FIG. **4J-2** is a cross-sectional view of the percussion tool **200** with the piston **380** in the down position **410** and showing the positioning of the at least one top exhaust conduit **430** in accordance with an exemplary embodiment of the present invention. FIGS. **4J-1** and **4J-2** illustrate the piston **380** in the same position as illustrated in FIGS. **4B-1** and **4B-2** since the piston **380** has completed one movement cycle. Since FIGS. **4J-1** and **4J-2** illustrate the piston **380** in the same position as illustrated in FIGS. **4B-1** and **4B-2**, the description previously provided with respect to FIGS. **4B-1** and **4B-2** also applies to the description of FIGS. **4J-1** and **4J-2**; and therefore is not repeated again herein for the sake of brevity.

Although a few exemplary embodiments have been described and/or illustrated with respect to the components used in fabricating the percussion tool **200** and with respect to the operation of the percussion tool **200**, modifications made with respect to these components and/or how the percussion tool **200** operates are envisioned to be included within the exemplary embodiments of this invention. For example, as previously mentioned, the check valve **302** may be placed upstream of the choke **360** or downstream of the choke **360**, such as within the bit **290**. Other types of modifications may be made such as reducing the number of components or increasing the number of components. Further, the connection type between the components may be altered without departing from the scope and spirit of the exemplary embodiments. Further, although the exemplary embodiments has been illustrated using a roller cone bit being coupled to the mandrel **270**, other types of bits may be coupled to the mandrel **270**, such as fixed cutter bits and hammers. Alternatively, these bits may be integrally formed with the mandrel **270** without departing from the scope and spirit of the exemplary embodiments.

Although the invention has been described with reference to specific embodiments, these descriptions are not meant to be construed in a limiting sense. Various modifications of the disclosed embodiments, as well as alternative embodiments of the invention will become apparent to persons skilled in the art upon reference to the description of the invention. It should be appreciated by those skilled in the art that the conception and the specific embodiments disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims. It is therefore, contemplated that the claims will cover any such modifications or embodiments that fall within the scope of the invention.

What is claimed is:

1. A downhole percussion tool, comprising:

a casing comprising a top end, a bottom end, and a casing passageway extending longitudinally from the top end to the bottom end;

a top sub coupled to the top end of the casing;

a drive sub coupled to the bottom end of the casing;

a mandrel being supported within a lower portion of the casing and extending through the drive sub and outwardly away from the bottom end of the casing;

a flow tube disposed within the casing passageway and comprising an inner wall and an outer wall surrounding at least a portion of the length of the inner wall from a top end of the flow tube, the inner wall defining a central channel extending the length of the flow tube, the outer wall and the inner wall defining an outer channel therebetween, the outer channel extending from the top end of the flow tube to a portion of the length of the flow tube, the outer wall comprising at least one opening therein;

a piston slidably mounted within the casing passageway above the mandrel and moveable to deliver an impact force onto the mandrel, the piston comprising:

an interior wall extending from an upper surface of the piston to a lower surface of the piston and defining a piston passageway extending therethrough, the piston passageway receiving a portion of the flow tube, the interior wall of the piston and the outer wall of the flow tube being positioned in close fitting relationship;

an exterior wall surrounding the interior wall and extending from the upper surface of the piston to the lower surface of the piston, the exterior wall and the casing being positioned in close fitting relationship;

a first conduit extending from the interior wall of the piston to the upper surface of the piston, the first conduit being in fluid communication with the at least one opening when the piston is at an up position;

a second conduit extending from the interior wall of the piston to the lower surface of the piston, the second conduit being in fluid communication with the at least one opening when the piston is at a down position;

wherein a portion of the casing passageway forms an upper chamber positioned adjacently above the piston and in fluid communication with the first conduit and forms a lower chamber positioned adjacently below the piston and in fluid communication with the second conduit, and

wherein the piston further comprises at least one exhaust conduit extending from the upper surface of the piston to a lower portion of the interior surface of the piston, the at least one exhaust conduit exhausting fluid from the upper chamber when the piston is at or near the down position.

2. The downhole percussion tool of claim **1**, further comprising a bit coupled to the mandrel and extending outwardly from a bottom portion of the mandrel.

3. The downhole percussion tool of claim **1**, further comprising a bit integrally formed with the mandrel.

4. The downhole percussion tool of claim **1**, wherein the at least one opening comprises a plurality of first openings and a plurality of second openings, the plurality of first openings being in fluid communication with the second conduit when the piston is at the down position and the plurality of second openings being in fluid communication with the first conduit when the piston is at the up position.

5. The downhole percussion tool of claim **4**, wherein the plurality of first openings are positioned elevationally above the plurality of second openings.

6. The downhole percussion tool of claim **4**, wherein the plurality of first openings are radially aligned.

7. The downhole percussion tool of claim **4**, wherein the plurality of second openings are radially aligned.

8. The downhole percussion tool of claim **4**, wherein the second conduit is positioned entirely below the first conduit.

9. The downhole percussion tool of claim **1**, further comprising a choke positioned at a top portion of the flow tube, the choke regulating the flow of pressurized fluid entering the central channel, the choke being replaceable.

10. The downhole percussion tool of claim **9**, wherein the choke is replaceable without dismantling the downhole percussion tool.

11. The downhole percussion tool of claim **9**, further comprising a check valve, the check valve being positioned in fluid communication downstream of the choke.

12. The downhole percussion tool of claim **1**, wherein the at least one opening comprises a plurality of first openings and a plurality of second openings, the plurality of first openings being in fluid communication with the second conduit when the piston is at one or more first intermediate positions, the one or more first intermediate positions being near the down position and the plurality of second openings being in fluid communication with the first conduit when the piston is at one or more second intermediate positions, the one or more second intermediate positions being near the up position.

13. The downhole percussion tool of claim **1**, wherein the at least one opening is fluidly coupled with only one of the first conduit or the second conduit.

14. A method of fabricating a downhole percussion tool, the method comprising:

positioning a piston within a casing and forming an upper chamber adjacently above the piston and a lower chamber adjacently below the piston, the piston comprising:

an interior wall extending from an upper surface of the piston to a lower surface of the piston and defining a piston passageway extending therethrough;

an exterior wall surrounding the interior wall and extending from the upper surface of the piston to the lower surface of the piston, the exterior wall and the casing being positioned in close fitting relationship;

a first conduit extending from the interior wall of the piston to the upper surface of the piston;

a second conduit extending from the interior wall of the piston to the lower surface of the piston; and

at least one exhaust conduit extending from the upper surface of the piston to a lower portion of the interior surface of the piston;

positioning a flow tube within the casing, the flow tube extending through the piston passageway, the flow tube comprising:

an upper portion extending from a top end of the flow tube towards a bottom end of the flow tube;

a lower portion extending from a lower end of the upper portion to the bottom end;

an inner wall extending from the top end to the bottom end and defining a central channel therein;

an outer wall extending from the top end towards the bottom end and surrounding a portion of the length of the inner wall from the top end, the outer wall and the inner wall defining an outer channel therebetween; and

at least one opening formed in the outer wall,

wherein the at least one opening is fluidly communicable with the first conduit when the piston is in or near an up position and wherein the at least one opening is fluidly communicable with the second conduit when the piston is in or near a down position, wherein the at least one exhaust conduit exhausts a fluid from the upper chamber when the piston is at or near the down position.

15. The method of claim **14**, wherein the interior wall of the piston and the outer wall of the flow tube are in close fitting relationship.

16. The method of claim **14**, wherein the at least one opening comprises a plurality of first openings and a plurality of second openings, the plurality of first openings being in fluid communication with the second conduit when the piston is at or near the down position and the plurality of second openings being in fluid communication with the first conduit when the piston is at or near the up position.

17. The method of claim **16**, wherein the plurality of first openings are positioned elevationally above the plurality of second openings.

18. The method of claim **16**, wherein the plurality of first openings are radially aligned.

19. The method of claim **16**, wherein the plurality of second openings are radially aligned.

20. The method of claim **14**, wherein the second conduit is positioned entirely below the first conduit.

21. The method of claim **14**, wherein the at least one opening is fluidly coupled with only one of the first conduit or the second conduit.

22. A downhole percussion tool, comprising:

a casing comprising a top end, a bottom end, and a casing passageway extending longitudinally from the top end to the bottom end;

a top sub coupled to the top end of the casing;

a drive sub coupled to the bottom end of the casing;

a mandrel being supported within a lower portion of the casing and extending through the drive sub and outwardly away from the bottom end of the casing;

a flow tube disposed within the casing passageway and comprising an inner wall and an outer wall surrounding at least a portion of the length of the inner wall from a top end of the flow tube, the inner wall defining a central channel extending the length of the flow tube, the outer wall and the inner wall defining an outer channel therebetween, the outer channel extending from the top end of the flow tube to a portion of the length of the flow tube, the outer wall comprising at least one opening therein;

a piston slidably mounted within the casing passageway above the mandrel and moveable to deliver an impact force onto the mandrel, the piston comprising:

an interior wall extending from an upper surface of the piston to a lower surface of the piston and defining a piston passageway extending therethrough, the piston passageway receiving a portion of the flow tube, the interior wall of the piston and the outer wall of the flow tube being positioned in close fitting relationship;

an exterior wall surrounding the interior wall and extending from the upper surface of the piston to the lower surface of the piston, the exterior wall and the casing being positioned in close fitting relationship;

a first conduit extending from the interior wall of the piston to the upper surface of the piston, the first conduit being in fluid communication with the at least one opening when the piston is at an up position;

a second conduit extending from the interior wall of the piston to the lower surface of the piston, the second conduit being in fluid communication with the at least one opening when the piston is at a down position;

wherein a portion of the casing passageway forms an upper chamber positioned adjacently above the piston and in fluid communication with the first conduit and forms a lower chamber positioned adjacently below the piston and in fluid communication with the second conduit,

wherein the at least one opening comprises a plurality of first openings and a plurality of second openings, the plurality of first openings being in fluid communication with the second conduit when the piston is at the down position and the plurality of second openings being in fluid communication with the first conduit when the piston is at the up position, and

wherein the plurality of first openings are positioned elevationally above the plurality of second openings.

23. A downhole percussion tool, comprising:

a casing comprising a top end, a bottom end, and a casing passageway extending longitudinally from the top end to the bottom end;

a top sub coupled to the top end of the casing;

a drive sub coupled to the bottom end of the casing;

a mandrel being supported within a lower portion of the casing and extending through the drive sub and outwardly away from the bottom end of the casing;

a flow tube disposed within the casing passageway and comprising an inner wall and an outer wall, the inner wall defining a central channel extending from the top sub and into the mandrel, the outer wall and the inner wall defining an outer channel therebetween, the central channel being isolated from the outer channel, the flow tube having one or more openings formed through the outer wall thereof;

a piston slidably mounted within the casing passageway above the mandrel, dividing the casing passageway into an upper chamber and a lower chamber, and operable to deliver an impact force onto the mandrel, the piston comprising an upper conduit in fluid communication with the upper chamber, a lower conduit in fluid communication with the lower chamber, and a passageway receiving the flow tube therethrough; and

a choke positioned at a top portion of the flow tube and operable to distribute flow of pressurized fluid between the central channel and the outer channel,

wherein:

the conduits are in selective fluid communication with the openings depending on a position of the piston, and

the flow through the central channel bypasses the piston.

24. The downhole percussion tool of claim **23**, wherein:

the flow tube has an upper opening and a lower opening formed through the outer wall thereof, and

the upper opening is in fluid communication with the upper conduit when the piston is at an up position, and

the lower opening is in fluid communication with the lower conduit when the piston is at a down position.

25. The downhole percussion tool of claim **23**, wherein the piston further comprises an exhaust conduit extending from an upper surface of the piston to a lower portion of an interior surface of the piston, the exhaust conduit exhausting fluid from the upper chamber when the piston is at or near a down position.

* * * * *